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# Educational Computer Activities and Problem Solving at the Kindergarten Level

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Québec

# EDUCATIONAL COMPUTER ACTIVITIES AND PROBLEM SOLVING AT THE KINDERGARTEN LEVEL

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# EDUCATIONAL COMPUTER ACTIVITIES AND PROBLEM SOLVING AT THE KINDERGARTEN LEVEL

by

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in cooperation with
La Commission scolaire Marie-Victorin
and
DIL International

Commissioned by Candide Pineault
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The ministère de l'Éducation du Québec has decided to extend its study of educational computer activities and problem solving at the kindergarten level. It has therefore appointed Charlotte Gélinas to conduct research on the integration of computers at the preschool level and to make suggestions and recommendations to the Ministère based on the conclusions reached in her study.

Charlotte Gélinas obtained her teacher's permit in preschool education and then taught kindergarten for four years. She was later granted a Master's degree in Education from the Université de Sherbrooke, where she studied the acquisition of language skills in early childhood. She then moved to Strasbourg, France, where she continued her studies in language acquisition and early childhood education, further developed her teaching skills through various intensive courses, and worked with young children from working-class and disadvantaged families.

"Any new problem requires a new solution."
Alain

"The role of the educator, according to Piaget, is to make students aware of problems rather than to provide solutions."
André Michelet

Charlotte Gélinas

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## PREFACE

The purpose of this study is to answer two key questions: How do microcomputers and selected educational computer games teach children to learn through problem-solving and how do computers develop children's cognitive skills?

To answer these questions, the author of this research paper spent a great deal of time visiting kindergarten classrooms in order to observe children organizing their own activities in groups of two to four according to the same rules and conditions as those applicable, for example, in the blocks or painting corner. The teaching approach used involved integrating the use of a computer into regular classroom activities. The children were given some initial activities designed to show them how to play computer games and some concurrent or later activities that allowed them to practice what they had learned and that fostered their creativity.

Though conducted over a very short period of time, this exploratory study has made it possible to compile and analyze a number of important observations. The conclusion reached was that computer activities provide a valuable learning context which both motivates children to explore and discover and helps them develop problem-solving skills and strategies. The use of computers and computer programs enables children to relate the information and knowledge they are acquiring to their environment in new ways.

This document, intended to be both educational and pedagogical in nature, is addressed to all those involved in any way in the education of preschool children. The contribution that computer games can make to the education of the kindergarten child is made evident in this study and is confirmed by observing children at work on computers.

Candide Pineault
Coordinator of Preschool Program
DFG/DGP

## INTRODUCTION

At present, the Québec kindergarten milieu could be described as a rich learning environment geared to enhancing the general development of young children who are about to begin their formal schooling.

The guidelines set by the ministère de l'Éducation du Québec in its 1981 **Curriculum for Preschool Education** recommend that this dynamic environment be continually adapted to meet children's needs, for it is the children who are the key force in the learning process: it is their individual needs and nature that shape how they learn and develop.[1]

The introduction of computers in our society at large and in our schools in particular (a change which is regarded as evolutionary, if not revolutionary) represents a challenge to early childhood educators. This new technological means of communication and of transmitting knowledge and information opens up a vast range of new, virtually unexplored avenues in many areas of life.

A number of questions now have to be answered: why and how should computers be used at the kindergarten level? Do they actually contribute to the development of intellectual skills or do they simply require the use of technical skills? Do computers really create new modes of learning that are likely to have a positive influence on the young child's emotional and social development and self-esteem as well as on his or her intellectual development?

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[1] Québec, ministère de l'Éducation, **The Curriculum for Preschool Education**, Code 16-1080A (Québec: ministère de l'Éducation du Québec, 1981).

## CHAPTER ONE
## DESCRIPTION OF THE PROBLEM

The purpose of this study is to provide insights into the contribution of computers to the educational process at the kindergarten level and an analysis of a number of educational computer activities in relation to the development of problem-solving skills.

A review of relevant literature was conducted prior to classroom observation. The documentation reviewed pertained to learning and the preschool child, the teaching/learning approach recommended in the Québec preschool program, the concept of problem solving at the kindergarten level and the introduction of computers in the kindergarten classroom.

Lastly, the behaviour of children engaged in educational computer activities was observed, and the observations noted down and analyzed in order to determine the possible behavioural implications of this new mode of learning.

### PURPOSE OF THIS STUDY

> The observation of preschool children in problem solving situations in the context of educational computer activities.

In order to assess the impact of the use of computers at the kindergarten level, it is important to study the new relationships they create:

1) the learner: the child
2) the tool: the microcomputer
3) the proposed educational computer activities

As Seymour Papert, the inventor of Logo and turtle geometry pointed out, "these new relationships are based primarily on a fundamental philosophy which states that the child wants to, and must, be the agent of his [or her own] learning."[2]

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[2] PIPTE Conference, Québec, 1983 as quoted in BIP BIP 35, April 1984.

In this context, it is important to consider the concept of problem solving and the related concepts of creative thinking and open and discovery learning. If at all stages of their development children in fact learn by seeing the impact of their actions on their environoment and from working with materials ranging from concrete objects to abstract symbols, it may be useful to determine exactly how the use of computers requires them to use cognitive strategies and thereby develops their thinking skills.

There are two reasons for the emphasis on problem solving in this study: in practical terms, the skills involved in problem solving are necessary for carrying out many kindergarten activities, and in theoretical terms, problem solving helps children to think for themselves and to retain flexibility in their thinking.

This research project involved doing a survey of relevant literature with respect to the following questions:

1) What are the psychological characteristics of five- and six-year-olds?

2) What does "problem solving" mean at this stage of development?

3) Which cognitive skills are developed through problem solving, in the context of this study?

4) How does the Québec preschool program incorporate this view of the teaching/learning process?

5) Do computers contribute to the development of problem-solving skills?

6) Does the educational software presently available in Québec promote the development of problem-solving strategies?

The final stage of this study consisted of observing children engaged in educational computer activities in the classroom and of analyzing their comments and drawings. From this process we were able to identify the key question to be answered: do computers and selected educational software create learning situations that require problem solving and promote the development of thinking skills, and if so, how?

Since another of our goals was to use the conclusions of this study as a basis for making concrete suggestions concerning the integration of computers in the kindergarten classroom, we bore the following questions in mind throughout the entire study:

1) Which type of computer activities sparked the greatest interest and motivation?

2) Can computer software provide learning contexts that reinforce skills which are being developed or learned?

3) How does the child interact with the machine, his or her peers, and adults when carrying out computer activities?

4) How much time should be dedicated to computer activities relative to other types of learning activities in the classroom?

## CHAPTER TWO

## REVIEW OF RELEVANT LITERATURE

This study of the microcomputer as an educational tool for fostering the development of cognitive skills in the preschool child (by means of problem solving) began with a survey of current research on the following topics:

**The Learner:**

- Piaget's theories of cognitive development and the present preschool philosophy in Québec
- Problem solving and the development of logical thinking in the child

**The Tool:**

- The use of computers for educational purposes and current applications in the preschool classroom; impact observed on children's development.

**The Content:**

- The criteria used for assessing the content of educational games and the adaptation of these criteria to a teaching/learning approach that involves problem-solving.

The following brief overview of the literature consulted is an attempt to provide at least partial answers to the questions raised in the introduction.

### PIAGET'S THEORIES OF COGNITIVE DEVELOPMENT

Each child is the architect of his or her own cognitive development. This phrase neatly sums up the theories of Swiss epistemologist Jean Piaget (1896-1980) in relation to the fundamental question "How do people acquire knowledge and learn?"

Piaget showed that concepts are never acquired in their final, perfect form, but rather that they are "constructed" through and in action (L. Not, 1983). Children learn and acquire knowledge through doing and experiencing.

Piaget observed that the more children interact with their environment, the more stimulated they are and the more interested and curious they become. Through these interactions, children build intuitive schemata. Kindergarten-age children build the rudiments of logical thinking by organizing their mental images; they develop a certain flexibility that enables them to anticipate the impact of their own actions. Young children's logic is limited by their cognitive self-centredness, by their assumption that the world really is how they perceive it to be.

Gradually, through interaction with their surroundings, children move away from their egocentric perceptions and are able to see the world as it really is. This outward-moving process, whether it involves the formation of social relationships or the acquisition of operational thinking, provides the basis of children's awareness of their environment. According to Piaget, this process, which is related to that of assimilation-accommodation, underlies the entire process of intellectual development.

The two processes of assimilation and accommodation enable children to make sense of the many different experiences (Piaget, 1967) they are constantly undergoing.

The developmental stage of children aged 3 to 6 is characterized by intuitive thought, by a progression from simple to more complex intuition, by the ability to make logical predictions or presuppositions and conclusions, all processes that are the beginning of logical reasoning based on mental images. Children this age are moving towards an understanding of numbers and the concept of conservation. They are experimenting with seriation and with non-figural collections.

At each stage of development, children are faced with things that are sufficiently beyond their intellectual level to require them to accommodate, but close enough that they are able to assimilate the new information or experience. As a result, the challenge facing teachers is knowing how to present the learning content to the child on the appropriate intellectual level, how to select ideas that can be assimilated

by young children at their particular stages of development and in their own individual ways in the here and now.

Cognitive psychologists, such as Bruner and his colleagues, developed theories parallel to those of Piaget. According to them, the child's intellectual development begins with simple actions, then progresses to image formation and the complex, natural manipulation of symbols. Bruner defines cognition as both a result and a means of interacting with the environment, the source of the raw material for intellectual development.

Piaget regards intellectual growth as an internal process, whereas Bruner regards it as both an internal and an external one. For this reason, Bruner stresses the importance of introducing children to technology, which, he believes, supplies the tools necessary for intellectual growth. Bruner places considerable importance on the role of schools and cultural institutions in exposing the child to this technological environment (Bruner, 1966).

Papert (1981) suggests that a computer-oriented environment provides children with new materials or subjects that may help them build and apply their thinking skills. He regards computers as a **plus** both in the learning process and in intellectual growth because they make it possible to represent, in more concrete and manageable form, abstract ideas or mathematical concepts that are not readily observable in the natural environment.

Papert thus proposes a teaching/learning process that involves the use of computers and that conveys ideas, concepts, and relationships. In this context, children would be allowed to use computers freely in order to explore and develop their own thought processes and actions. This approach incorporates the conditions necessary for Piagetian learning: the discovery of knowledge through motivated personal action and experience, through interaction between subject and object.

Children question, act and then observe the impact of their actions in order to adapt them in light of what they have learned about causes and effects. This involves active learning through constant interaction with their surroundings and without a pre-established program (Papert, 1981).

Learning in this way fosters not only intellectual development, but also social and affective growth and child-adult interaction.

The learning process involves important personal factors that trigger the desire to learn and help the learner consolidate the knowledge acquired. Morgan (1979) stresses motivation as the prime factor. Gordon (1979) focusses on the affective relationship between teacher and student. Correl (1978) relates lack of motivation to lack of maturity. Paré (1977) underlines the importance of reality as the basis for learning. Gagné et al (1976) state that experimentation, comprehension, decision-making and reflection are the building blocks of knowledge, while Krech et al (1979) define learning as problem solving through creative thinking.

Many different schools of thought concerning psychology and education have contributed to the current philosophy of preschool education in Québec and are evident in the 1981 program. They include Montessori, Decroly, Dewey, Gesell, Erickson, Piaget and Rogers.

## PRESCHOOL EDUCATION IN QUÉBEC

Preschool education in Québec is intended to promote the overall development of the child's personality. The child is at the heart of the preschool program of the ministère de l'Éducation du Québec.

Each child comes from a particular home background that has made its mark on his or her personality. Often the child has attended a daycare or had some form of preschool education either in a school (at four years of age) or an in-home daycare setting. He or she has generally watched somewhere between two and three thousand hours of television, which represents a great deal of information and images. Television has already influenced the child's cultural perceptions.

The MEQ program describes children as unique, dynamic beings with a desire for learning (notably through play), capable of acting on their own,

aspiring to creating their own view of the world, and needing support, assistance, nurturing and stimulus as they integrate what they perceive through interaction with their environment. Children generate their own experiences by integrating their knowledge into the connections they have already made in their efforts to understand their environment (accommodation, assimilation, harmonization.)[3]

This open teaching/learning approach hinges on the child. As the main agents of their own development, children are encouraged to make choices, to evaluate the impact of their actions, to deal with new experiences, and to try to discover how facts interrelate. In this approach, a dynamic environment that offers many problem-solving opportunities is provided, an environment in which activities (and the knowledge and skills they involve) are not ends in themselve. This is very different from an approach that is centered on the acquisition of knowledge as a foundation for acquiring more knowledge. The latter is a mechanistic view of how children learn and reflects a linear and closed philosophy of education.[4]

The atmosphere in a classroom is created by the children in it. The children are stimulated and motivated by the many and varied materials available, by social interactions with their classmates and their teacher, the adult role model. The role of the teacher is to present children with challenges and problems that are appropriate to their individual abilities and levels of development, and to create an atmosphere of mutual trust and respect in the classroom. The teacher's three-part objective is that defined in the Québec preschool curriculm: to help the child develop self-awareness, form relationships with others, and interact with the environment.[5]

"These [principles] are founded on fundamental values such as respect for others and sensitivity to the main features of human growth, values expressed in . . . the overall plan for education in Québec. [6]

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[3] Québec, ministère de l'Education, **The Curriculum for Preschool Education**, Code 16-1080A (Québec: ministère de l'Éducation du Québec, 1981), pp. 11-12.

[4] Idem, p. 8.

[5] Idem, p. 13.

[6] Idem, p. 9.

Given the nature of the program, its objectives and the numerous strategies that can be used to attain these objectives, it can be inferred that computers and an appropriate computer-oriented teaching/learning approach could easily be integrated with other kindergarten activities whose purpose is to foster children's development at the opportune moment and in the appropriate way.

Since computers are of major interest and are having a marked effect on today's society, schools cannot afford to ignore them. As J. and C. Pillot (1984) emphasize, "teaching, training and learning in general are all challenged by these new tools: the kindergarten classroom is no exception."

**LEARNING THROUGH PROBLEM SOLVING**

The concept of problem solving is a matter of interest to both cognitive psychologists, pedagogues and educators. Depending on the way of thinking, problem solving is defined as a mental process, a type of behaviour, the accomplishment of a specific task or a learning process.

Newell and Simon (1972) present a cybernetic model of thinking (data processing). Resnick and Glaser (1976) examine the cognitive skills involved in the problem-solving process; Yussen and Santrock (1982) and Ester (1985) study problem solving as an intellectual phenomenon that contributes to the development of children's thinking skills. Krech et al (1979) relate creative thinking to problem solving.

While studying problem solving in relation to computers, Douglas H. Clements (1985) and Sandra Munro-Mavrias (1985) identified three types of skills or abilities involved in the problem-solving process:

- memory, indispensable for recalling and retaining information relative to the problem;
- convergent thinking, or logical reasoning, combined with the ability to discriminate and categorize objects or events, the ability to apply rules and principles to new situations;
- divergent thinking or intuitive/creative thinking, combined with the related ability of organizing or reorganizing information according to desired results.

In a situation where the goal necessitates looking for the appropriate

means of attaining the goal, the individual must be actively involved, thereby using his or her cognitive skills (attention, perception, memory, observation, induction, inference) and applying problem-solving strategies that reflect his or her ability to identify, discriminate, orient, order, classify, sequence, evaluate, associate, compare, analyze, draw analogies, and so on.

According to Bruner and Gooknow (1956), the steps a person takes in trying to solve problems do not consist solely in making associations determined by prior experience, but also in making decisions in a kind of back-and-forth interaction between the subject and the objects or events involved.

The problems to solve may be common, unexpected, or unfamiliar. Dealing with the first type of problem involves development, with the second type, adaptation, and with the third, originality, ingenuity or creativity, depending on how much that particular type of behaviour is valued (Cloutier, 1981).

In all cases, the intellectual process involves closing the gap between the known and the unknown. To achieve this, the individual must make choices, apply the chosen solution and reutilize this solution when confronted with similar types of problems.

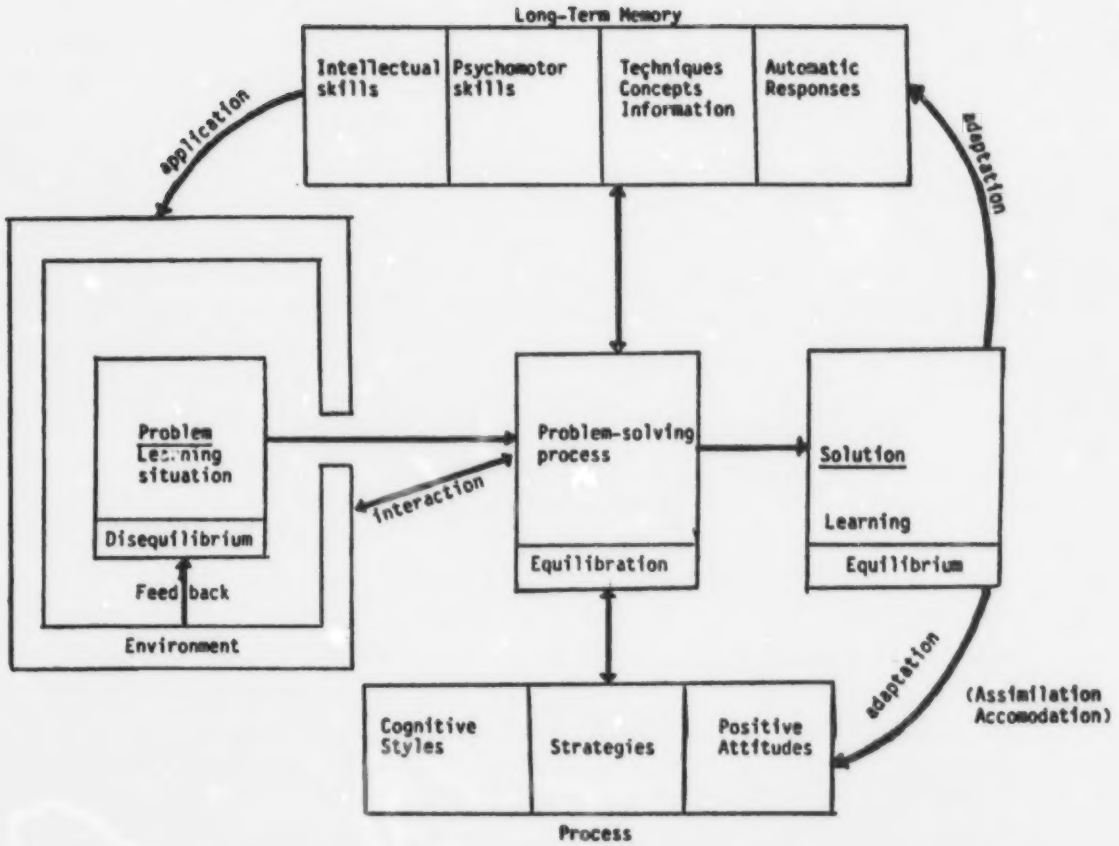
This process is called non-specific transfer: the knowledge that a person has acquired makes him or her more effective in subsequent activities. This type of transfer is central to the learning process, that is, to the continual process of expanding and refining knowledge with general basic ideas (Bruner, 1966).

Two factors must be considered in "solving a problem": the solution and the process. At the outset, the subject must be aware of a specific goal to attain, namely, the solution. Then, increasingly complex mental activity takes place over a period of time and requires mental processes defined in psychopedagogy as well as processes related to specific fields of knowledge: this is the process. Between the beginning and the end of this thinking process, a new "level" of knowledge has been attained and a certain degree of satisfaction achieved (B. Morin, 1984).

The chart on the following page depicts the problem-solving process as an

interaction between a subject searching for a solution (disequilibrium) and the environment, which provides feedback on the appropriateness of his or her strategies and behaviours. The person gradually finds the solution (equilibrium), which he or she is later able to use again in other situations due to long-term memory.

# THE PROBLEM-SOLVING PROCESS




This chart by Marcel Hamel (commission des écoles catholiques de Sherbrooke) was referred to by Claude Gaulin, professor at Université Laval, during a lecture given by him in 1981 at the Université du Québec at Chicoutimi.

In terms of the learning process, problem-solving could be defined as a means of acquiring knowledge through heuristics, that is, through questioning and discovery. Most modern cognitive psychologists use the term "problem solving" to designate this process, also known as productive thinking. The teaching/learning approach involves teaching how to go about solving a problem, and is not concerned with finding the solution itself; in other words, the child learns how to learn (De Flandre, 1986, 1985). This type of teaching is called the discovery method or the active method by Dewey, Bruner, Piaget and Rogers. It calls upon the mental faculties of creating, organizing, and interrelating in different ways in order to go beyond the usual limited uses of these faculties and functions (Krech, 1979).

The advantages of this type of learning are that it brings about:
- changes in the person's thinking processes;
- definite learning, since the child is directly and actively involved;
- learning in which knowledge opens the doors to more knowledge due to the learner's ability to interrelate and apply knowledge that has already been acquired;
- increased intellectual autonomy;
- intrinsic satisfaction as a result of personal discovery, and increased self-confidence (de Flandre, 1986).

It is important to note that children may acquire problem-solving skills at different ages provided that the problem presented is appropriate to their intellectual level of development. Their levels may range from concrete operational to formal thinking.

## PROBLEM SOLVING AT THE KINDERGARTEN LEVEL

Children have an innate ability to solve problems. This is how they learn intuitively and how they continue to learn in kindergarten. Early childhood educators have come to recognize that an environment rich in problem-solving situations is the one most likely to help children construct the mental schemata defined by Piaget.

S.G. Goffin (1984) and C. Tull (1985) both observed that the more able children are to interrelate things, events and ideas, the more able they are to give meaning to the realities around them and to find answers to questions such as "What will happen if I do this? If I do this first, what will I be able to do next?" How come these things don't go together?" These questions, which are often implicit, precede the stage of actual experimentation.

Many opportunities arise in a kindergarten classroom for creating game situations that present a problem and for providing a wide variety of means of finding the solution: blocks, playacting, puppets, arts and crafts, scientific experiments, and so on. The objective of kindergarten is not to convey ideas per se to children, but to spark their creativity by allowing them to discover their own solutions.

From this perspective, the teacher's role is to propose situations, challenges and problems that are within the children's grasp so that they can relate them to their personal experience or to what they already know. The teacher encourages the children to plan ahead and to anticipate the effects of their actions. He or she also encourages them to make decisions and to observe the results of their actions.

It is important to note that children do not always understand how they manage to solve a problem and that it is possible to help them verbalize and reflect on their actions (reflective thought). The results will be new thought structures (Clements, 1985).

This type of learning involves a child/adult partnership. Piaget describes the educator as a guide who encourages initiative and inquiry (1964). The inquiry process is a joint effort with the educator playing a peer who is "in the know" as to where and how to obtain the necessary information

(Loranger, 1985). The educator resists the temptation of showing the children the solution in order to allow them the pleasure of finding their own solutions.

## TYPES OF PROBLEMS APPROPRIATE FOR KINDERGARTEN

Various types of problems are recommended for K (kindergarten) children:

- those concerning motion: the movement of the body in space;

- those involving language skills: talking in a group about problems to be solved, discussing possible solutions;

- those involving intellectual skills: problems that require observation, classification, formulation of hypotheses, sequencing, shape and number recognition skills, and so on;

- those concerning strategies that can be made up or decoded; analyzing intuitive problem-solving processes.

For the purpose of this study, we shall adopt the view of the aforementioned authors and shall regard problem solving at the kindergarten level as an opportunity for children to experiment creatively with a variety of concrete or symbolic objects, in various ways, with a view to achieving a desired goal relatively directly and quickly.

In keeping with this view, the educational software and hardware used in a kindergarten setting should present challenges that are within the students' capabilities.

The criteria for sound K-level problem-solving software can be defined as follows, according to S.G. Goffin and C. Tull (1985):

- Are the problems understandable? Is the object of the game easy to identify?

- Do the problems require thinking skills that the children have already acquired or ones that they are in the process of acquiring?

- Does the activity require decision-making?

- Are there several possible solutions or approaches to the problems?

- Does the activity encourage the children to take concrete action, collect information and solve the problems?

- Can the children observe the effects or results of their actions? Does the software give any feedback?

- Does the software create situations that encourage the children to share their opinions and cooperate?

Several examples of software that provides good problem-solving situations will be discussed later in this report.

## COMPUTERS AS LEARNING TOOLS AT THE KINDERGARTEN LEVEL

Little research has been done to date on the impact of computer learning at the preschool level. This is due to the small number of computers as yet present in kindergarten classrooms and to the lack of assistance and support available to teachers to help them integrate computer activities into their teaching.

Researchers have observed that today's children regard computers with the same kind of fascination and interest as their parents did television sets and other audiovisual devices (M. Spencer, M. Baskin, 1983, Taylor, 1983). The TV monitor is even somewhat reassuring to children because of its similarity to the familiar TV screen (Krieger, 1984).

Many families in all classes of society have computers in their homes, and it has become evident that young children three to four years of age are able to use these machines to learn, simply by trying out different keys (experimenting) to see what will happen (discovery) (Lee, 1983).

As Micheline Labelle (1985) points out, computers and children are compatible because children approach the machines without any preconceived ideas and are therefore readily motivated, interested and

amused. Their approach is basically one of trial-and-error at their own skill level, and this approach is a reinforcing one that encourages them to continue with the activity.

The authors of the studies consulted for the purposes of this report more or less agree on the following points:

- After only a few sessions, children are able to use the computer and peripheral devices on their own and know the appropriate terms for each. They quickly pick up the required "technical" skills (Chauvin and Eimerl, 1983; Pillot, 1984; and Campbell, 1986).

- In the groups observed, the children's motivation and interest levels remained very high beyond the initial excitement over a new toy; all the classes in which computers were installed asked to keep them (J. and C. Pillot, 1984; Neiboer, 1983; Klinzing, 1985).

- Children clearly display pleasure when using a computer. Perlman (1976) even states that the most important thing children can learn from using a computer is that learning can be fun.

- The interactive nature of computer learning is directly related to the interactive nature of the computer (the computer reacts to the child's action, and the activity stops if the child stops responding). The child is guided by various types of auditory and visual signals from the computer. This type of interaction leads to a auto-instructional (*autoinformation*) process, as defined by Pillot and Pillot (1984) and A. de Bork (1981).

- Individualization: Children using computers receive feedback regarding their own decisions and actions (whether they are using the keyboard or a graphics tablet). Each child learns at his or her own pace and each learning experience is unique (Pillot and Pillot, 1984). In A. de Bork's view (1984), computers actually humanize education.

- Learning through computer games cultivates the most natural and effective way children have of developing their minds, imaginations and senses (Nieboer, 1983; de Bork, 1981): play. The "play" appeal stems from the quality of the interaction between the player and the computer-toy and from the child's attraction to the sound, animation , color and graphics used (Pépin and Leroux, 1984).

• Eye-hand coordination is developed through the use and coordination of the screen and keyboard or the screen and graphics tablet (Niebaer, 1983; Pillot and Pillot, 1984). In his work, Krieger (1984) also noted a widening of the field of vision.

• Development of cooperative behaviour also occurs: The children acting as onlookers share their comments and opinions with the player. Having a few children use the computer together stimulates social interaction (Borgh and Kickson, 1983); Sheingold, 1986). This type of associative and cooperative participation of the onlooker has not been observed in any other kindergarten activity (Klinzing, 1985).

• Development of self-confidence through computer games seems to stem from the nonjudgemental nature of the learning experience, in which the reinforcement provided encourages the learner to continue until he or she has succeeded in achieving the desired outcome. The computer leaves no evidence of the learner's errors and can repeat the activity endlessly. The learner does not develop a negative attitude since he or she perceives error as a simple "episode" in a series of "comebacks," rather than as a sanction or punishment (Schwartz, 1981). The child also experiences a feeling of control over the machine, thereby deriving considerable satisfaction from using it (Taylor, 1983; Spencer and Baskin, 1983).

• Development of relatively structured logical thought and of personal discipline occurs because the computer does not negotiate or bargain with the child: the child must adapt to the intrinsic logic of the machine and of the program. The difficult or impulsive child quickly learns that the computer will not cooperate if he or she does not follow the rules. A number of necessary operations must be performed in a specific order. For example, the child must insert a diskette in the disk drive, turn the computer on, and wait for the program to load (Taylor, 1983). The computer is ideal for learning by trial-and-error, a mode of learning that is particularly appropriate for young children and that encourages them to reflect on their own thought processes (Papert, 1981).

Computers can be described as "symbol" machines. They are therefore well suited for kindergarten children for they are at the age when they are learning to understand and manipulate symbols. Language, pictures,

drawings, gestures, numbers, and so forth, all represent meaningful objects, ideas or feelings.

Much like other materials used in the kindergarten classroom (paints, plasticine, percussion instruments, blocks, and so on), computers too provide children with symbolic interaction. Computers are basically "symbol dispensers" (Sheingold, 1986) and in this respect are no more or less natural than books.

Ideally, according to Sheingold, computers are instruments that give children the opportunity to manipulate symbols in creative, original ways just as easily as they would paint, or construction games, for example.

In his study on the relevance of computers to the kindergarten level, R. Nieboer (1984) comes to the conclusion that computers contribute to the development of fine psychomotor skills, language, creativity and problem solving on both social and technical levels, and that they also encourage children to experiment and to formulate hypotheses in order to successfully complete the task at hand.

## COMPUTERS AND PROGRAMS FOR KINDERGARTEN CHILDREN

Numerous studies and experiments indicate the prevalence of two approaches in educational software:

- a programming-oriented approach intended to develop children's ability to predict the outcome of their actions (motion, transposition from Euclidean space to projective space ) using geometric intuition;

- an approach based on more traditional games that develop skills and concepts such as observation, shape recognition and matching, spatial orientation, vocabulary, identification of similarities and differences, sequencing, visual memory, association of ideas, creativity, numeration, and so on.

One difference between these two approaches is particularly significant. In the more traditional educational game activities, the object of the game is predetermined by the programmer: the number of possible solutions is limited. With the Logo-type approach, in contrast, the object of the game

is determined by the child, who then gives the computer or the turtle instructions in order to attain this objective.

Papert (1981) wonders whether children could not learn to talk to the computer, hence his Logo programming language. In keeping with Piaget's teachings, Papert is convinced that children develop their own thinking processes and proposes culturally relevant computer material designed to help children in their cognitive, affective, and behavioural development and the formation of their self-image.

With this in mind, several American, French and Canadian researchers such as Campbell (1986), Spencer and Baskin (1983), D. Clements (1985), Chauvin and Eimerl (1984), and Munro-Mavrias (1985) have observed the behaviour of children using Logo language.

D. Clements (1985) and Munro-Mavrias (1985) observed no significant differences in intellectual development between two groups of children, one group using Logo and the other group using different educational computer games. In both cases, the children developed their thinking skills, the only difference being that the children who had been introduced to programming obtained better results on tests that involved the ability to give directions and analytical thought (metacognition).

It should be noted that the children's progress could not be quantified as no adequate measurement instruments have yet been developed to measure the effectiveness of computer-based learning.

The two approaches discussed above most certainly have different effects on cognitive development, but both require exploration, anticipation, self-correction, and the formulation and verification of hypotheses.

Since existing studies are too recent to have assessed objectively whether the children involved have made any real, sustained progress, there is an obvious need for both long-term studies and the creation of appropriate measurement instruments.

# CHAPTER THREE

## METHODOLOGY

The three reasons for studying children involved in educational computer activities are to determine:

- the effects of the computer as a means for learning through problem solving;

- the effectiveness of educational computer games in creating situations requiring problem solving (the content);

- the kinds of problems that should be proposed to children in computer activities.

In order to accomplish our objective, we set up a "computer" activity corner in a classroom, established a method for using selected materials, introduced the children to the materials and how to use them, and defined consistent observation criteria.

### 1. SUBJECTS UNDER OBSERVATION

This study was conducted in a kindergarten class of 19 children, aged 5 to 6, including 10 girls and 9 boys. Their school was located in a rural setting. Five children were familiar with computers because their families each owned one. Four other children had played on a computer belonging to a close friend or relative of the family. The other children had never used a computer prior to this experiment.

### 2. METHOD

**Setting Up the Computer Corner:** We did not want the computer corner to be regarded as an out-of-the ordinary, temporary novelty. Our goal was to duplicate as closely as possible the conditions under which any material is normally used in a classroom: an area managed by the children and subject to the same rules as the other activity areas in the room, such as the block

or doll corner, or the sandbox, where small groups of two to four children can play at a time.

A computer station was therefore set up in a comfortable part of the classroom away from the noisiest activities and separated from the rest of the classroom by a bookcase. The computer was placed parallel to the windows in order to prevent the glare and reflection of light on the screen.

**Time Allotment**: The time allotted for computer activities was comparable to that allowed for other free activities, that is, the children could choose to do a particular activity for a one-hour period and then move on to another corner or station if space was available there. The children were helped to manage the activity areas by themselves by posting pictures of them to indicate who was involved in which activities and whether or not there was room for more participants. The children negotiated among themselves (with the adult's help) the successive trading of places for the more popular activities so that everyone was guaranteed a turn.

In the case of the computer corner, each child was allowed to play two games and then he or she had to move on to another activity. Each game lasted an average of 2 to 3 minutes, for a total time of 6 to 8 minutes on the computer. Not all the children wanted to do computer activities, some came only on occasion, and others, rarely.

The aim of the approach used was to integrate the computer into the usual classroom activities by offering preparatory pre-computer activities to the children and concurrent or follow-up activities to allow them to practice their skills and use their creativity. The pre-computer activities involved the whole class, whereas the actual computer games were done in groups of around three children. Follow-up was done with the entire class or with individuals, as deemed appropriate.

Two approaches were used to integrate the computer into the classroom. In the first, the teacher would structure all of the activities (pre-computer, computer and follow-up) around a specific theme such as the zoo, the beach, or the computer. These themes were introduced through stories, each with a specific theme and socio-affective quality.[7] The second approach

7 The resource guide and student workbook that come with DIL International software suggest numerous activities for integrating and making use of the themes in the classroom.

involved structuring activities around a specific concept or skill (shape recognition or matching, for example). In this case, the level of difficulty was increased gradually by beginning with simple programs and moving to more complex ones.

The main objective was to start at a level the children could handle and to help them progress by allowing them to experiment with:

- concrete, three-dimensional objects;

- symbolic representations (drawings and pictures) through exercises and paper and pen activities;

- the projective space on the screen, by allowing them to manipulate more abstract symbols and then return to the concrete to practice and assimilate the new skills they had learned.

Logical thinking skills are acquired gradually, as André Michelet (1972) correctly points out: it is impossible for the young child to separate logical thinking from its affective and concrete dimensions. Michelet also expresses concern about involving children too early in games of logic because, he feels, when introduced too soon or too exclusively, such activities may result in an extremely narrow channeling of thinking skills. He would prefer to see logical concepts integrated into the child's sensorial experience, in other words, used to create a bridge between the pre-logical and the logical thinking skills that are intermingled in the young child's mind.

The mind needs matter in order for thinking to take place: we believe that the more opportunities children are given to go back and forth between the concrete and the abstract, the more this will enhance their problem-solving skills.

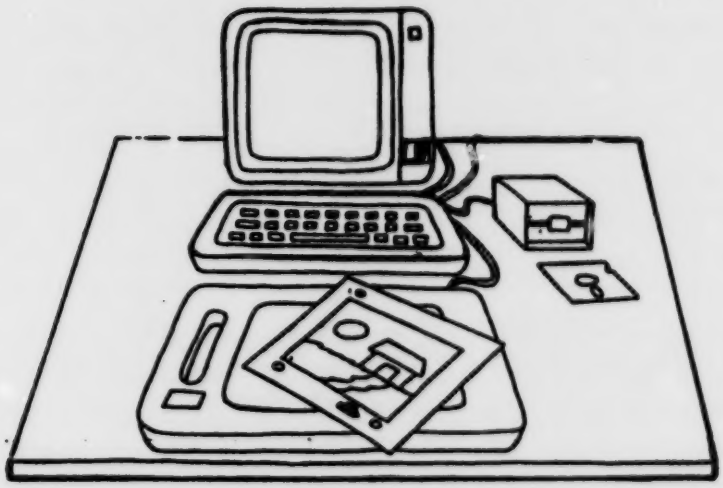
**The Observer's Role**: The observer's role was to watch the children carry out their activities and to record their reactions. An extension of this role was to encourage the children, not by providing any clues to the solution, but rather by prompting them to think for themselves by means of reformulating the problems involved in the activities.

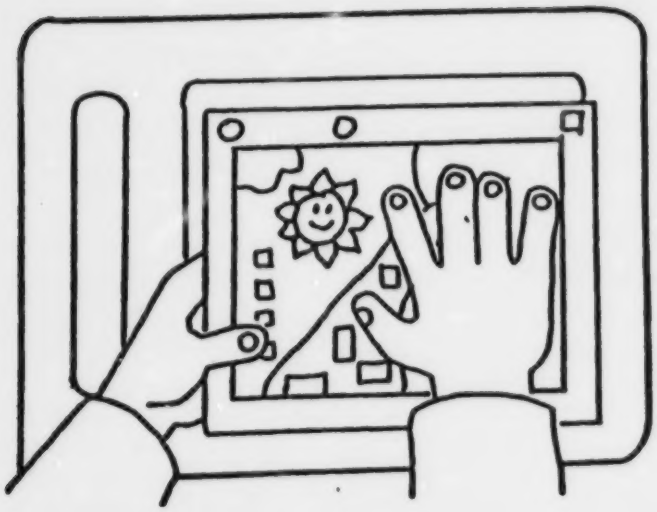
The observer was occasionally called upon to create and modify the strategies used to present the computer activity, as necessitated by this study. However, the teacher was always the person in control of the classroom.

**Duration of the Observation Period**: The children were observed 2 or 3 times a week over 12 consecutive weeks. In addition, 2 or 3 children between 2 1/2 and 7 1/2 years of age were observed simultaneously, briefly and regularly, in order to verify certain data and phenomena recorded or observed during the classroom sessions.

## 3. MATERIAL

An Apple II with one disk drive and a graphics tablet (called WonderWorker) were installed in the classroom (see the illustration on the next page).





The WonderWorker is an input-output device with a 32 cm by 32 cm touch-sensitive surface. The child responds directly by pressing on the illustration placed over this touch-sensitive surface and therefore does not need to use the keyboard. No prior knowledge of numbers or letters is required. The only skill needed is that of being able to press on the illustration with the right pressure and at the right pace (not too quickly) to enter information and respond to the machine's cues. The tablet is not excessively sensitive so that it does not pick up involuntary movements, thereby preventing any possible confusion in the child's mind.

An overlay complements the picture on the screen: part of the game is illustrated on the overlay, the other part, on the screen. The child's hand movement on the overlay brings about changes on the screen (visual feedback) and elicits auditory feedback as well. These signals guide the child as to the next step.

**The Educational Software Used:** A number of programs designed by DIL International were used in class during the observation phase of this study. As no appropriate hardware (Commodore 64K) was available from the school board, it was unfortunately impossible to use "Mimi le Fourmi 1 and 2" by Québec author Anne Bergeron (distributed by Logidisque).

DIL software offers a range of activities, most of which are educational games designed to develop the cognitive and sensorial awareness of 3- to 8-year olds. The expressions "Computer Assisted Learning" (C.A.L.) and "Thinking Skills Software" are generally used to describe this type of software.

DIL software and the accompanying educational materials were developed for the purpose of educating children rather than of introducing them to computers and computer skills per se.[8] Its objectives[9] are:

- to familiarize children with computers and peripheral devices;
- to help them acquire the appropriate vocabulary;
- to make them aware of the interactive nature of computers;
- to help them recognize the various roles that computers can play: teacher, simulator, tutor;
- to sharpen the children's ability to pick up and interpret visual and auditory signals;
- to develop their fine psychomotor skills and eye-hand coordination;
- to help them develop thinking skills such as association, recognition, discrimination through representative thought (manipulation of symbols), logic and reasoning (recognition of cause/effect relationships, anticipation, decision-making);

These computer activities, according to their author, should "motivate the

8 "Education par le jeu et l'environnement," 2nd quarter, 1985, Paris.

9 Resource guide, Mademoiselle Merveille Series, Guérin Publishers, 1985.

learner to personal action and develop his or her curiosity, initiative, and autonomy." This in turn "encourages interaction and cooperation with peers." The play aspect is the key motivational device in the DIL activities.

The activities are divided into groups of 10 under specific themes: The Country, The Zoo, The Birthday Party, The Beach, The Circus, The Library, The School of Architecture, The Secret, The Computer. Various complementary non-computer activities are suggested to prepare the children for the software activity, or to develop the socio-affective theme of the story that comes with the software.

Colourful illustrations on plastic-coated, double-sided overlays constitute the media with which the child will work. By pressing on the desired object, the child gives his or her response to the challenge or problem presented on the screen and receives visual or auditory feedback. Standard symbols are used throughout the program. The child presses a green circle to load the game, a red circle to pause, a yellow circle to return to the menu or to start over. The child can work through these activities on his or her own since the commands are simple to use and the materials are durable.

## 4. THE OBSERVATION INSTRUMENTS

In order to determine which types of behaviours should be noted and to draw up appropriate observation checklists, we began with a pre-observation phase.

### Pre-Observation Phase

The computer and peripherals were brought into the classroom shortly before Christmas as gift-wrapped boxes.

The children responded to the new toy with enthusiasm and curiosity. They looked forward to using it.

Their first question --"How does it work? How do we play?"--was initially answered by means of a demonstration and explanation given by the teacher. Each child was also given a hands-on turn with the materials.

The second question--"Who is going to play? Can we all play?"-- led us to

set the rule that "everybody will get a turn." This rule was readily accepted by all since it had been in effect in the other activity corners since the beginning of the school year.

Two activities from "The Computer" package were used to allow the children to familiarize themselves with the operating instructions: "Mystery Boxes 01" and "Plugs and Sockets 02."

By introducing the computer in this way and giving the children a chance to use it, the observer was able to make notes on the children's behaviour and attitudes and to define what could observed objectively and what could not.

This pre-observation period was relatively brief: It consisted of 7 sessions during which all of the children used the two programs at least twice. The following conclusions were reached on the basis of these sessions:

- it is easy to monitor the children's interest and motivation by observing their impatience when waiting for their turn on the computer, by the pleasure they show when their turn comes, by the amount of time they spend on the computer, and so on;

- it is possible to observe whether the children are developing autonomy gradually or suddenly;

- it is not possible to determine which thought processes are involved when a child has put together the elements leading to a solution;

- it is possible to observe the social behaviours of children as they play on the computers: cooperation, leadership, and so on;

- it is often possible to determine from the children's comments how they approached the problem at hand, whether through trial and error or through a conscious effort to recognize similarities, differences, and so on;

- it is possible to observe how often a child asks for help from adults or other children and what kind of help is requested;

- it is possible to observe whether a task is too easy (the player loses interest quickly), appropriate (his or her interest was maintained), or too difficult (the discouraged child stops playing);

- it is possible to determine whether learning has occurred by observing whether the child makes progressively fewer errors, but it is difficult to infer which strategies were used.

The conclusions drawn from the results of the pre-observation phase led us to focus our study on the interactive relationship since it is one of the main characteristics of both computers and problem-solving strategies:

- child-machine interaction;
- child-peer interaction;
- child-adult interaction.

The first step toward solving a problem is to identify the problem. For this purpose, it was necessary to determine and to record whether or not the children understood the object of the game. This required talking with them.

The children's overall attitude and their ability to re-orient their strategies in response to errors served as measures of their problem-solving skills.

The pre-observation phase led to the design of the following observation checklist, which was used throughout the observation stage to record the children's behaviours on the computer.

## OBSERVATION CHECKLIST

Date:_____ Program:_____

Perserved ☐
Gave up ☐

No. of observers: _____
Understood instructions: _____

### Interaction

child/machine

- understood pictures _____
- understood sounds _____
- understood relationship between his/her actions and changes on the screen _____
- reaction to success _____
- reaction to error _____

child/peer

- asked for help _____
- when offered help.....accepted ☐ refused ☐
- took part in discussion_____
- expressed objections _____
- offered approval/encouragement _____
- gave advice _____
- interfered _____

child/adult

Asked adult to:
look ☐
assess ☐
explain ☐
help ☐

ATTITUDE

Overall:
enthusiastic ☐
impulsive ☐
inhibited ☐
thoughtful ☐

| Main strategy: | at outset | during the activity |
|---|---|---|
| none (at random) | ☐ | ☐ |
| trial and error | ☐ | ☐ |
| methodical | ☐ | ☐ |

Other sources and methods were used to obtain additional information that was impossible to collect through observation only. This information was needed in order to confirm or invalidate hypotheses based on observation.

Additional methods used were:

- recording the children's verbal interactions during computer activities;

- occasional conversations with the children;

- talking with the teacher, who was involved in the computer activities and who observed the children's behaviour on a daily basis;

- analyzing work produced by the children during the preparatory or follow-up class activities or during spontaneous activities.

## CHAPTER FOUR

## CLASSROOM OBSERVATIONS AND THE RESULTS OBTAINED

Following the method and time allotments described in the preceding chapter, we completed our observations of the kindergarten students during the second term of the school year.

Three or four sessions were first used to introduce the children to the equipment and two programs from the series *Fée et Charmant à l'ordinateur (1-0,2-0)*. During this period, the adult had to exercise a certain control over the learning of the operations and their proper execution. The children were allowed to play freely on the computer and to run progressively through the gamut of games whose main themes were the Zoo, the Beach and the Computer. Some other games, whose theme made it possible to concentrate on a particular skill, were also added.

In order to keep this report brief, we have selected examples of the most significant games (and the related observations) in an attempt to answer the questions raised in this study. The main points covered in these questions are:

- the interest shown by the children and their motivation while playing;
- their ability to adapt to this new type of game;
- their ability to transfer and reapply what they learned;
- the pattern in the number of errors made by the children over time;
- the role of social interaction;
- the problem-solving strategy most often used by children;
- their ability to explore space and to anticipate outcomes;
- their ability to break down difficulties into manageable parts;
- their ability to talk about actions as part of the learning process;
- the characteristics of software designed for problem solving, as well as the study of children's behaviours in response to different levels of challenge.

The interest shown in the computer continued beyond the initial period of curiosity and excitement and was evidenced by the fact that the children sought to be at the computer corner as often as they sought to be doing the most popular classroom activities. Such enthusiasm was confirmed in a study done by K. Kinzing (1985) on the popularity of the computer. It showed that, by and large, children tend to choose this workshop as often as they do other activities such as the arts, cooking, science activities, sand, water,

or language play. However, he also observed that five-year-old girls in particular tend to choose the computer more frequently than they do building blocks.

The children's perseverance in playing on the computer could be considered a good indication of their interest in and motivation for this type of activity. If left to play at leisure, the children are able to focus their attention and concentrate on the computer for 15 to 35 minutes (Spencer and Bastin, 1983). We were able to verify this fact outside the classroom context with 4 1/2 and 5-year-old children.

In the classroom, we noted that no children left the computer during their activity and that they always found it difficult to leave the machine when their time was up.

Malone (1980), as reported in Spencer and Bastin (1983), points out that children derive such pleasure from playing with an educational computer game that they are motivated to play longer with it than with any other educational material. Perhaps the greatest source of motivation to play is the interactive nature of working with the computer and the play aspect conveyed by the animation, colour, graphics, and sound effects.

The children's interest and enthusiasm for computer games were confirmed by their parents' responses to a questionnaire which we sent them concerning their child's experience at school. [10] All of the children in the class had talked about the computer to their parents; 18 out of 19 of them had given their parents the impression that they had enjoyed using the computer.

## ASSEMBLY GAME ON THE COMPUTER INVOLVING DIFFERENTIATION BETWEEN SHAPES AND SIZES:

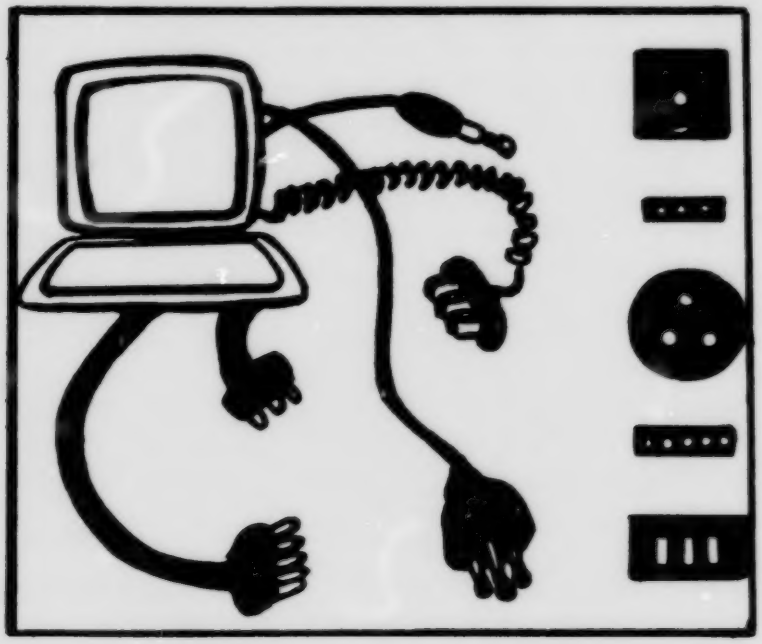
### PLUGS AND SOCKETS (2 - 0)[11]

We witnessed the children's first attempts at playing with the program Plugs and Sockets (from the collection referred to earlier) on the theme of the computer.

[10] Cf Appendix I.

[11] The labels and descriptions used for the software programs mentioned in this report were inspired by the work of Denise Garon, author of the ESAR system for classifying games and toys (1985).

This game makes the children aware that the computer and its peripheral devices are linked to one another and that they run on electricity.



Plugs and Sockets (2 - 0)

In terms of cognitive skills, the object is to learn to match objects which can be distinguished by their shape and by the number of their component parts. The child should then be able to distinguish whether or not the plugs all have the same number of prongs and, if they do, whether or not they are different in terms of their size or thickness.

In this game situation, the problem-solving process requires two levels of competence: knowing how to use the computer and knowing how to recognize similarities and differences in order to complete the game.

In terms of technical skills, we noted that the children needed only two or three sessions to familiarize themselves with the operations required to start up the computer, to change diskettes, to match the diskette with the

appropriate game, as well as to use the graphics tablet to input their response.

Some of the more impatient or impulsive children learned to adapt their pace to that of the machine (only one response can be entered at a time and the user must wait for the result to appear on the screen before entering another response).

When the children were unsuccessful, they never blamed the computer (childish animism could have been a factor here), but instead asked themselves what the matter was or for the opinion of children nearby or the opinion of the teacher.

A genuine feeling of cooperation developed among the children grouped around the computer so that the game could continue; they offered advice, directions, and suggestions, and sometimes took over operations when necessary, all in a spirit of "helping out."

The children were required to remember different sequences and to adapt some of their visual-motor skills since, for the first time they were working in a two-dimensional space projected before them (the screen), not directly, but by means of an intermediary (the graphics tablet), on which they had to press in specific places.

This type of problem was new for the children and forced them to apply the rule of cause and effect: "What I do on the screen has such and such an effect." For five-year-old children, this brief exploratory experience (the experience would be somewhat longer for three- and four-year-olds) constitutes a particular type of play activity: they have control over the machine.

Jean Destrooper (1985) speaks of a new language in relation to computers, a language which permits a very important dialogue between the eye and the brain, freeing the hand and thereby creating a totally original form of game.

As for the game itself, the children generally tackled it with enthusiasm, their glances going from the picture to the screen with a happy, curious attitude, looking for clues that might guide them to make the right decision and the right movement.

The children never appeared to use chance as their main strategy. They did not do things randomly simply to see what would happen. If there were

signs that their hypotheses were false, then certain children would quickly and systematically try out all other possible responses. Close observation of the children in this instance revealed significant individual differences in their level of maturity or in their individual methods of problem solving. 12

After matching similar clues ("This plug has three prongs, this outlet takes three prongs") the children did not always make the appropriate decision ("This is the right button, I will press it") because children this age can usually remember only one criteria at a time: they can remember that either the size or the number (1 to 3) corresponds, but they have difficulty retaining both criteria at the same time. This was the problem encountered by most of the children. On their second or third attempts, they overcame the problem through greater concentration and by memorizing the correct response each time a wire appeared connecting the right plug with the right outlet. When they chose an incorrect plug, sparks "appeared" to indicate an electric shock; the children found this computerized effect very amusing.

The sounds that informed the children of the rightness or wrongness of their choices appeared to have little impact on them; the normal classroom noise virtually blotted out these sounds. However, a workshop after class in which classroom noise was not a factor did not produce any differnt results. This phenomenon needs further study.

One basic rule in this program complicated the task: a chosen plug has to be matched with an appropriate outlet; if the wrong outlet is chosen and needs to be changed, the user has to point out the original plug again and then choose the correct outlet, otherwise the "connection" cannot be made and the confused child will wait in vain for something to happen.

Once this rule has been understood, it appears to help some students to make a decision. The process of making a definitive choice ("this plug goes with this outlet") discouraged systematic exploration.

**Comments**

In this type of problem, the appropriateness of the level of difficulty is reflected by the number of errors made by certain children, errors indicative of the lack of concentration that is normal at this age. The tendency to make errors can also be increased by other factors such as

12 Further research on the "visual" or the "auditory" approaches to problem solving would undoubtedly point up some interesting differences in the two strategies.

impetuosity, carelessness, or excitement due to the novelty of the activity.

The number of errors made by the children after their first or second tries gradually decreased until they reached a solution to the problem.

The children learned either by taking into account the two criteria (number and size of the prongs), or by trial and error and memorizing spatial clues (the plug on top goes with the outlet on the bottom, and so on) or by both. It was still not always possible for us to determine exactly how children resolve problems either through our observation or by talking with the children.

When using other, similar computer programs, it is easier on the one hand to identify the children's level of competence, and on the other, to allow them to develop and consolidate this skill of association, which is a prerequisite to understanding certain mathematical concepts. Using Goffin and Tull's description (1985) of a valid problem for the kindergarten level (on page 22 of this text), it appears that this software did have some of the qualities needed to develop students problem-solving skills if we judge by the fact that the children were able to:

- recognize the nature of the problem;
- understand that a solution could be found (in this case, by appropriate pairing);
- recognize different shapes and complementary sizes (skills already acquired or to be reinforced);
- look for relationships by trial and error or through intuitive reasoning (at different levels);
- make decisions (choices);
- recognize immediate feedback in response to their choices (they are on or off track);
- exchange information and points of view with their peers.

It can also be concluded that the problem was meaningful: it is interesting to learn how the computer can be hooked up and supplied with electricity. The children's motivation was sustained by the play aspect of the program.

## THE TRANSFER AND APPLICATION OF LEARNING ACHIEVED THROUGH COMPUTER GAMES

The first computer game done in class drew our attention to the concept of transference, which is part of the learning process inasmuch as it reflects

and extends the application of the initial learning. "Learning in which no transference takes place is learning in appearance only" (Aufauvre, 1980). Learners who have acquired a certain skill can be recognized by their ability to use the knowledge they have learned (R. Hofman, 1986). Children who are stimulated to act and think through computer games should be able to see the relevance of what they have learned to their other classroom activities.

The teacher, whose role is in part to create a wide range of activities designed to stimulate the children's progress, can help them apply their learning by presenting situations in which they alternate between manipulating concrete objects and manipulating concepts, and vice versa.

It is not a question here of "teaching" in the traditional sense, but of soliciting the children's attention by suggesting a variety of learning situations that allow them to make inventive use of their intellectual skills. Games involving observation, discussion, creativity, and investigative skills, among others, should have themes (as is the case in the previously mentioned software) such as pairing, matching, or identifying differences and should allow the children to determine for themselves the criteria for grouping.

In a teaching approach geared to problem-solving, all learning situations must provide opportunities for the children to relate what they already know to what they are having to learn.

The program **Introduction to Mathematics**[13], reminds us that "all learning depends upon the personal experience of the individual," and recommends making maximum use of objects and materials in the classroom. The approach proposed in this Mathematics program is that of "experimentation, followed by action and verbal and graphic communication" at the child's level.

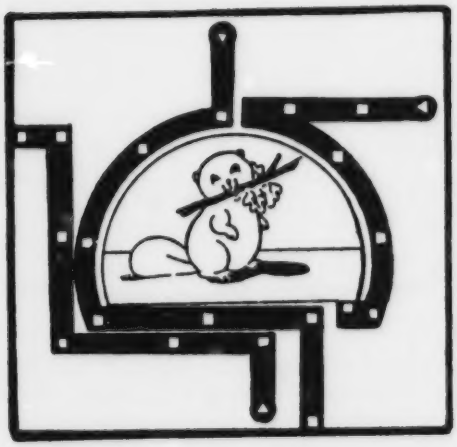
A teaching approach based on the integration of computer activities into regular classroom activities implies that the software used as teaching material should sometimes be used to initiate activities and at other times as an additional resource. The play appeal of computer software motivates children to play while learning and to learn while playing because it allows them to manipulate symbolic representations, symbols which they would otherwise have few opportunities to manipulate.

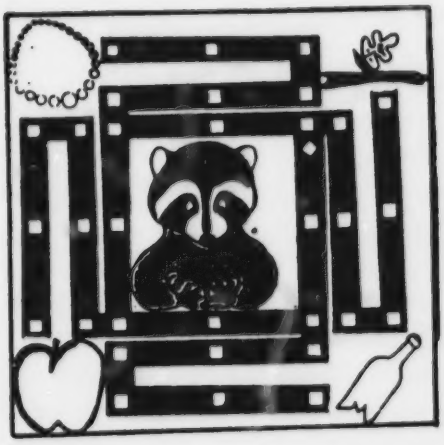
[13] Québec, ministère de l'Education, **Introduction to Mathematics**, Code 16-1008A (Québec: MEQ, 1977).

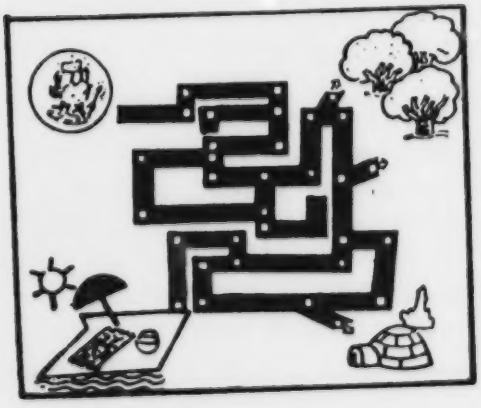
## A GAME OF SPATIAL ORIENTATION: THE MAZE

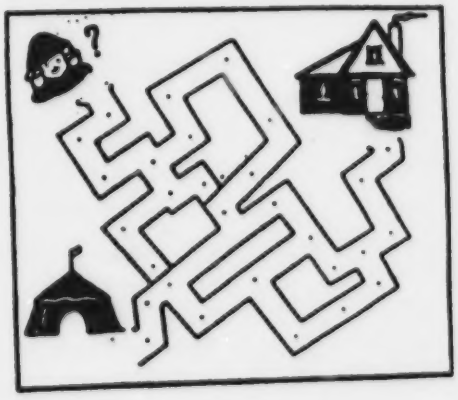
Games involving mazes help to reinforce the students' understanding of spatial representation; these games involve open space, closed space, and an analysis of space.

Several games involving computerized mazes of varying difficulties were utilized by the children in the classroom under observation. They included Beaver-Maze, Muskrat-Maze, Beach-Maze, House-Maze, and Parent-Search.









This type of game helps children to play in a space that is representative of the space they live in, of the space in which they are learning their own location and that of other people or objects. We believe that in this context, the computer motivates and encourages children to explore and that it provides a means for them to try out and experiment with what they are learning about the world around them. The problem presented is that of locating spaces and of anticipating the results of specific movements.

The first game the children played, Beach-Maze (3-P), indicated that they were essentially unfamiliar with this type of problem. They showed great interest in cautiously trying to discover (step by step) the effects of their actions on the acreen. Initially, they had difficulty understanding the objective of the game and sometimes gave up midstream, sacrificing the learning process for the end discovery: "What will happen if I go in this direction?" A second problem was that of eye-hand coordination; the children had a hard time finding where they were in the game if they removed their finger from the graphics tablet; they then had to compare the picture on the screen with the picture on the tablet. This problem decreased the longer the children played, and they soon learned to keep their fingers on the picture in order not to lose their place.

The major problem they had was being able to anticipate the effect of their action visually; some children would go to the very end of the route they had chosen before realizing that there was no exit; they were not thinking of trying to minimize the number of movements they had to make as they played.

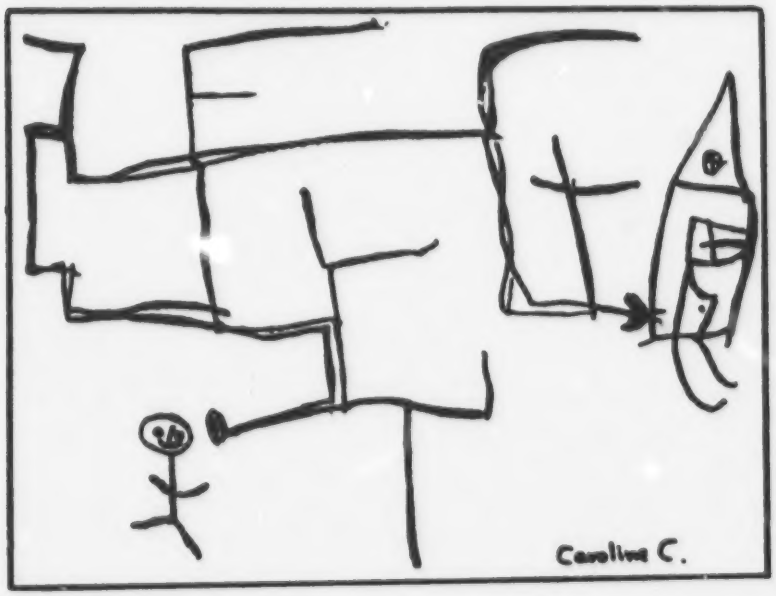
In order to give the children a clearer understanding of the problem presented in this maze game, we proposed the following approach to be used in class. It consisted of four steps:

1. The teacher illustrated on the blackboard a very detailed story describing the long, complicated road that a child takes to go home. The route was based on those taken by the children in the classroom to reach home either on foot or by bus.

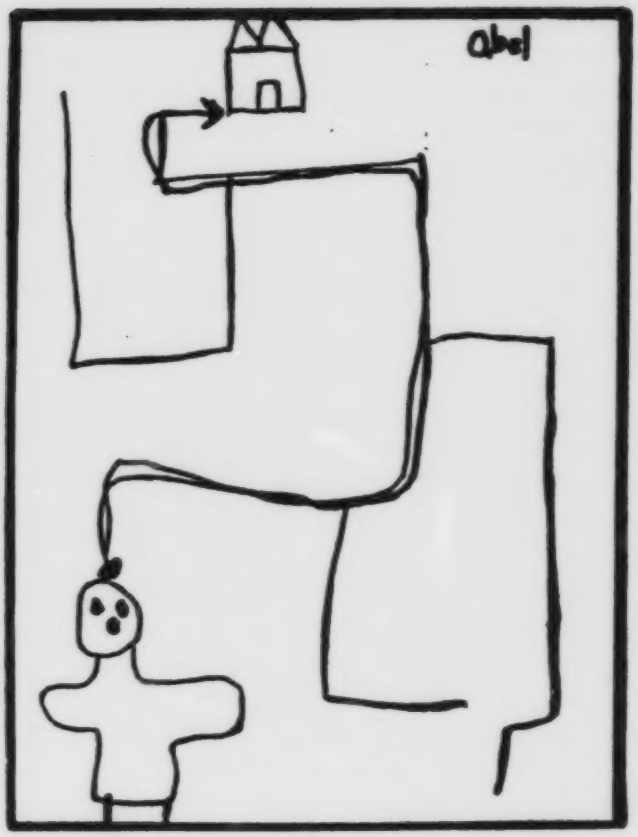
2. The children were asked to build mazes on the floor. To do so, they worked in small teams and used building blocks to make interconnected roads and some roads with no exits. They were told to imagine that a small car was driving along the road to a particular destination, the zoo, which was represented by an animal. They then had to switch places with other

teams and to try to find their way through classmates' mazes.

3. They then did the same kind of game on paper. They were asked to draw their homes with a number of roads in the vicinity, including some roads that did not lead to their home. Two drawings were chosen from those done in this exercise. These drawings were photocopied and presented to the class, who then had to try to find the way to the student's home.




Examples of mazes drawn by children in the class and solved by their classmates




Some computerized maze games -- House-Maze, Beaver-Maze, and Muskrat-Maze -- were left for the children to do at leisure along with other games. They thus had the chance to become more familiar with this concept of space. They gradually did less systematic exploration of all the different routes and more guessing about how to reach the end of the maze.

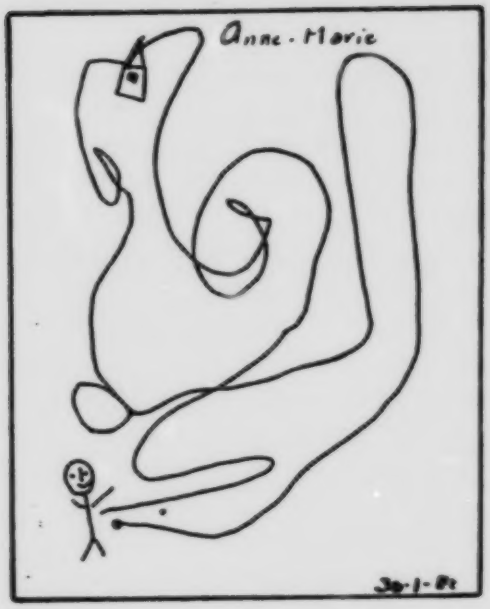
All the children refused to let others interfere directly in their game; some refused all offers of help, but the majority welcomed the opinions and suggestions offered by onlookers.

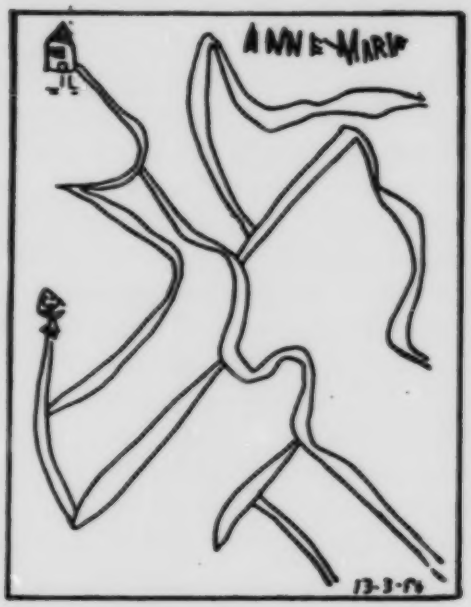
The more the children learned, the faster they played; they expressed their growing satisfaction with smiles and exclamations such as "I got it!" However, it seems that with maze games, the real pleasure was simply that of interacting with the computer; the children were not aiming for instant success, or to make no mistakes, or even to finish quickly.

In the games House-Maze and Beaver-Maze, the computer buzzes to inform the children that they they have chosen a wrong route and gives a visual cue for them to begin again. In the Beach-Maze game, some friendly animal graphics appear on the screen to indicate a wrong route; we noted in this case that the children deliberately sought the pleasure of seeing the graphics rather than the solution itself. This may be indicative of children's main motivations; evidently, the objective of the game needs to be clearly defined as well as the means of achieving it.

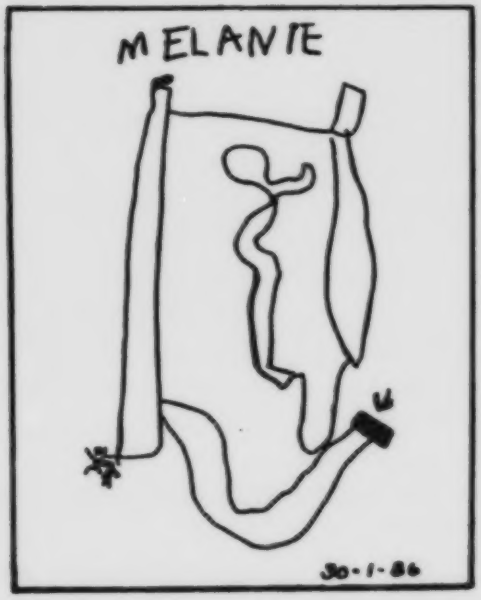
4. The children were asked to do another drawing on the same subject: their home and the streets all around it. Most of their drawings demonstrated marked progress in relation to their first drawings done two weeks earlier. Some drawings revealed a better understanding of multiple and connecting roads, even though the concepts of dead-ends and through roads still seemed unclear. The ability to make up a plan is even more indicative of learning than simply being able to play a game.

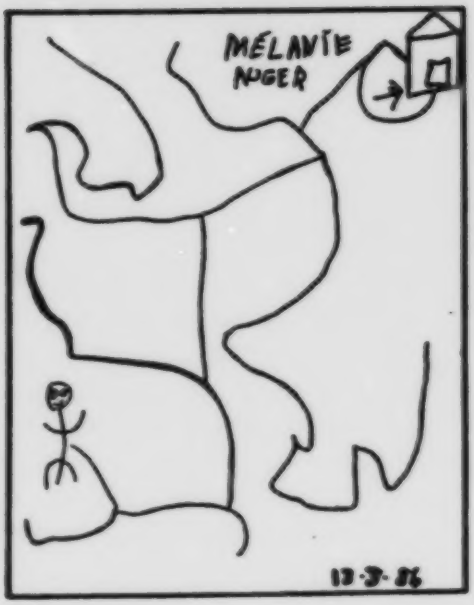
Progression in two students' maze drawings after a few weeks of unlimited access to computerized maze games




(The child who drew this maze told us that the roads in her drawing were not dead-end.)



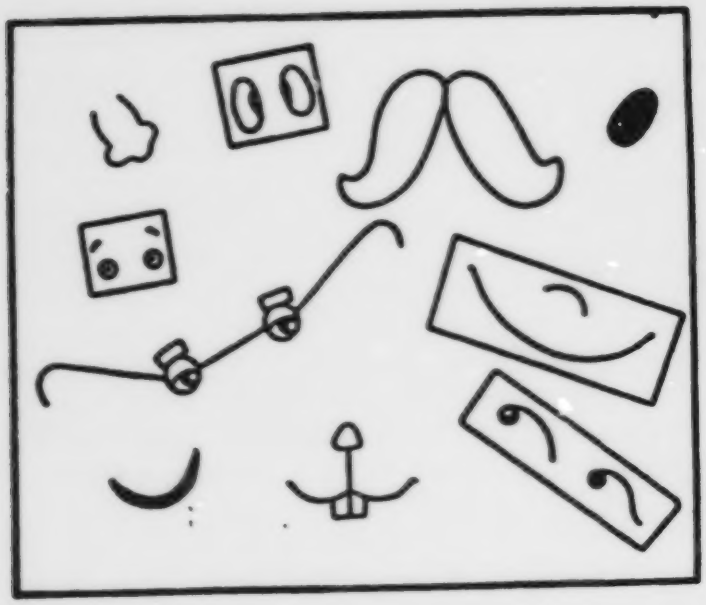



## ASSEMBLY GAME THROUGH IDEA ASSOCIATION: FACIAL FEATURES (3-E)

### Rationale for the Choice of Software

The game Facial Features is representative of several of the other assembly games in the game collection we studied. The object is for the children to find the links between the different items shown.

In order to analyze the children's verbal interaction, we recorded their conversation as they played this game. Two children were given the game to play with for the first time with no restraints; they repeated it endlessly until they had had enough and were left completely free to play at their own pace and to say whatever they wished without being inhibited by the presence of an adult.



Copy of the picture on which the children entered their answers

### The Problem or Challenge Presented in This Game

The picture on the previous page, placed by the student on the graphics tablet, shows a variety of facial features: eyes, noses, mouths, and moustaches. Some are the features of a little girl while others are those of a school caretaker. The only thing that appears on the computer screen is the outline of the two people's faces. The children have to choose one feature at a time and indicate their choice by pressing on the picture in question at a specific place on the face (indicated by the blinking cursor on the screen). There is no model to follow; they are free to think back on the pictures of the story they have heard, or to make logical associations and to use their imaginations.

### The Children's Verbalizations and Their Relevance to the Study of Problem-Solving Strategies

In our view, the recordings made of the children's conversation while they played the computer games provided an invaluable complement to our written observations, which told only part of the story.

These recordings made it possible for us to identify some of the types of interactions that occur during the problem-solving process, notably the offering of encouragement, requests for information, answers to questions, providing information, offering suggestions, criticisms, or complaints, laughing and exclamations, instructions from the teacher, answers given by the teacher, and periods of silence.[14]

The frequency of these different types of interactions was studied by Klinzing in 1985. Their frequency varies depending on the children's ages. For example; children who are four years of age tend to laugh, encourage each other and make exclamations more often than children who are five years of age; the latter tend to play more quietly. Klinzing believes that the novelty factor encourages children to talk more. Nieboer (1983) also noted that the more familiar the children are with the machine, the less they tend to talk.

The context in which we placed the children during our observations more or less reduced the role of the adult to that of an onlooker. This explains the lack of verbal interaction with the adult in the transcripts of the recorded

[14] We had one difficulty in analyzing the recording: when the child asked a question, it was not clear whom the question was being addressed to: to him- or herself, or to one of the onlookers?

conversations.

### The Transcripts of the Verbalizations of Two Children Playing "Facial Features"

The following conversation took place between two children, M and N, who were five and five and a half years of age. They were unfamiliar with the game, but had had previous experience with other computer games. By analyzing their conversation, we tried to identify some of the skills and strategies used in problem solving.[15]

Their verbalizations reveal some of the different intellectual processes involved. We have tried to identify these processes.

[15] An effort was made to identify the children's attitudes while their conversation was being recorded, but only a video recording would give an truly accurate picture.

## TRANSCRIPT 1

| Conversation Between M and N | Observer's Interpretations |
|---|---|
| N plays while M watches. | |
| M: Look at the dog's tail!<br>M and N: both laugh. | Makes exclamation in response to the appearance of the animal graphics in the game. |
| N: What does the little black dot mean? | Is paying attention; looking for clues and information. |
| M: It means . . . It means . . . | Idem. |
| N: The eyes are missing! | Forming a hypothesis: the blinking cursor must indicate the place where the eyes are supposed to go. |
| M: Yes. | Offers approval, the uncertainty stops. |
| N: Presses on the eyes wearing glasses; the buzzer indicates a wrong answer. | |
| N: The man doesn't wear glasses. | The original hypothesis proves wrong. |
| N: I pressed there! | Verifies hypothesis; recognizes error. |
| M: Try the mouth. | Suggests another possibility. |
| N: (after trying). No, that's not right either. | Again recognizes error. |
| M: The moustache! | Expresses surprise, no objection, the right answer. |

After two tries, the right answer shows at the top of the screen. The blinking cursor now indicates an area of the little girl's face.)

| | |
|---|---|
| Children are quiet. | Looks quickly at features. |
| N: Where are the glasses? | N. wants to put the glasses on the girl because they did not go on the man. Hasty deduction because there are four pairs of eyes. |
| M: Glasses on the little girl? | Disagrees with the hypothesis. |
| N: Well . . . maybe the eyes? | Makes new hypothesis. |
| M: She has small eyes. | Remembers the *Fée* in the storybook. |
| N: (Enters the answer) Yeah!<br>The mouth is underneath.<br>The two mouths are not the same.<br>(Enters answer) | Recognizes success.<br>Locates, pinpoints.<br>Compares, differentiates, chooses, decides. |
| M: Yeah! | Approves, happy exclamation. |
| N: Oh! The nose, I forgot the nose. | Chooses from three possibilities. |
| M: (Points at a nose.) Press on that one. (Laughs.) | Makes funny suggestion. |
| N: No, silly, that's a rabbit's nose! | Responds to the suggestion after considering it. |
| (Laughter)<br>The nose and mouth of a little girl. | Identifies, forms new hypothesis. Makes decision. Right answer. |
| (Success. N. raises arms in the air.) | |
| N: The moustache, I put it in the right place. | Remembering the last try, concentrates on the exact height: aware-<br>ness of a subtlety? |

| | |
|---|---|
| N: Well then, what goes above it? | Locates: looks back and forth between screen and picture. |
| M: The eyes | Suggests hypothesis. |
| N: Oh yes, the eyes. | Agrees, quickly chooses eyes. |
| M: No, not those ones! | Criticizes choice. |
| N: The glasses first. | Tries out uncertainly, possibly remembering first unsuccessful attempt. |
| M: Try them! | Encourages, seems sure of himself |

(The glasses appear in the right place on the screen.)

| | |
|---|---|
| N and M: Yeah, yeah, yeah!<br>(laughter) | Pleased at their success. |
| N: The nose, there's no nose. | The blinking cursor catches their attention. |
| M: Give her a red nose. (Laughter) | Makes suggestion for the fun of it. |
| N: That's good, Maxime.<br>(Laughter) | Amused at funny combination. |
| (Silence) | Looks for a suitable feature. |
| (Success) | Chooses. |
| N: You see, Maxime? The mouth is red. | Looks at evidence, makes quick decision. |

(Visuals appear on the screen)

| | |
|---|---|
| M: You did it, now it's my turn. | Recognizes success and acknowledges it. |

(The problem was solved, the images on the screen indicate success. End of the game.)

**Comments**

Certain facts stood out from our analysis of the children at play.

- the children are the key actors in the learning process;
- the interaction with the computer (which immediately verifies the children's responses) guides the learning process;
- communication with the observer provided stimulus and challenges;
- the children were strongly motivated to play and had good concentration; they displayed their satisfaction with their success very openly.

Initially, the child knew the objective he was working toward, but not how to achieve it. Several items appeared on the picture and he had to make a choice. Before making his choice, we can infer that the child had to relate the different elements involved: 1) the area of the face, 2) a feature that would be appropriate to this part of the face, 3) a feature suitable to the person in question. This involved having to look closely at and being able to interpret the features shown.

Second, the child was obliged to interpret the buzzer as the cue for him to enter his response (making a deduction based on the part of the face where the cursor was blinking in anticipation of a response).

Finally, the child had to interpret the computer signals.

The child's first tries were logical, but not successful, and he therefore had to introduce a new element into the data: accuracy. There is one and only one facial feature that belongs to this particular part of the face, and therefore only one answer that is right.

Having learned this, the child is able to progress quickly, making use of his ability to concentrate, observe, remember, deduce, infer, locate, choose, and decide.

The child who is playing is responsible for his own decisions. The responses on the screen that indicate success reinforce the learning that is taking place and encourage him to continue playing. Achievement of the objective is indicated by the appearance of the final graphics on the screen. The child smiles in satisfaction. The acknowledgment of success offered by the

classmate who is observing is appreciated by the player.

After the first child has played, the child who has observed takes her turn. Presumably she has learned something from watching hers classmate and will find the game easier to play.

## TRANSCRIPT 2

M plays while N watches.

N: Your turn, Maxime.

M: What goes at the top?

N: His glasses.

M: Yes, that's right. They don't disappear.

N: The nose.

M: Yeah, that goes. Does the mouth go there?

N: The moustache! It's in the right place.

M: Good! . . . the little girl.

N: The nose, the nose!

M: No, her eyes.

N: Her nose.

M: Not so high!
Let's try this.
Yeah, yeah, I see.
The mouth . . the mouth is in the right place.

M: That's it, I've finished. The computer will erase everything.
Let's change games.

(End of game)

**Comments**

The second child, who saw the game being played before taking her turn, was enthusiastic and sure of what she was doing. She also understood how the game worked and consequently made fewer errors; some of her own hypotheses were tested when the first chi'd was playing; she had had the

chance to observe which answers were right, to decide on their suitability, and to remember the solutions.

The student who is now observing makes suggestions. Both player and observer discuss and verify the hypothesis made; the player makes an exclamation "Oh, now I understand" (we believe she understands that the nose and mouth of the little girl are interrelated). It seems logical to think that the second child is able to play and complete the game quickly mainly because of what she learned by participating actively when the first child was playing.

## TRANSCRIPT 3

N plays while M watches.

The game starts.

N: I'm going to try to do everything right off the bat.

N: There are the mouth and nose.
That's right. The eyes go over here.
. . . (works quietly)
. . . I've done everything except for the mouth.
Which mouth is it? This one?

M: Yeah, the nose, yeah.

N: I did it, yippee!

(End of game)

**Comments**

N was playing the game for the second time. The goal he set for himself was to play without making any errors. He played the game easily, quickly, and with great concentration. The only time he had to be especially careful was when he was identifying the parts of the face and entering the right answers. He was visibly pleased at his success. The child has mastered the problem at his level of understanding.

The child observing plays a less active role this time. Her role is to doublecheck and to encourage the player in his choices.

Judging from the changes between these three transcripts, it can be concluded that the children learned something, that they know more after playing the game than they did before. Their competence is probably due to:

- the cognitive skill of associating the different elements;
- their ability to adapt their behaviour to an unfamiliar aspect of the game: the importance of locating position accurately;
- their ability to remember the information acquired.

This three situations and their results are a relatively accurate reflection of the learning process and of the types of problems that the learners

encountered during our classroom observations, regardless of whether the game involved ideas association, the observation of differences and similarities, ordering logial sequences or visual memory.

A large number of games of varying difficulty (from simple to complex) brought to light the specific play behaviours of individual children (more or less impulsive or thoughtful), but also the particular difficulty of the task at hand. Some children would comment that the game was easy, while others would say that they would find it more interesting if it were more complicated; they would try to make the activity more difficult themselves by not wanting to be told, for example, the object of the game so that they could discover it on their own. Some expressed the wish to use the keyboard or asked if they could go faster, while others (very few) needed reassurance in the form of very simple exploratory activities to bolster their self-confidence.

The most stimulating situation with regard to problem solving was, however, the one in which a learner was playing a new game for the first time: he or she would use all his or her abilities in an active search for the solution. The children observing would cooperate and at the same time, be learning 'something'; when they took their turns on the computer, they had the opportunity to verify what they had already learned and to go further by trying to make fewer errors and to play more quickly.

Occasionally, a more timid or less tenacious child would simply follow the directions given by his or her classmates, but this tended to occur less and less often the more familiar the child became with the activity and as his or her self-confidence grew.

A number of different behaviours were observed, including leadership qualities ("I'll show you"), dependency ("What should I do?), defensiveness ("Don't touch my game"), willingness to negotiate ("Okay, but afterwards it's my turn"), and the ability to acknowledge success ("He's good). These behaviours reflect the social or interpersonal problem solving that was noted in the way the children handled all such popular activities.

After an initial period of adjustment and familiarization with computer activities, the children demonstrated autonomy, perseverance, pleasure, interest, and willingness to cooperate when playing on the computer.

The inherent limitations of this type of game must, however, be recognized. After playing a few times, the children know the solutions to the puzzles by

heart and are ready for new challenges. It is up to the teacher to ensure that the children keep striving to expand their horizons beyond the superficial aspect of the problems presented by continually providing the best possible learning environment.

Our exploration of learning situations by means of this software led us to consider another type of game. In this second type of game, the object is not to find a solution that has been predetermined by the program, but to create one's own challenge by making the maximum use of the elements available and of the many possible ways they can be combined.

## GAME INVOLVING ARTISTIC ASSEMBLING OF GEOMETRIC SHAPES AND SPATIAL ORIENTATION: *GÉOFORME* (6-0)

The computer games that were available to the class gave us the chance to study a type of software described as "open-ended." This term refers to the fact that the games have several possible solutions, depending on the player's level of satisfaction or his or her achievement of the goal that he or she has set. This type of game is quite unlike games which have only one solution even if the objective can be achieved in different ways.

### The Game and Its Objective: *Géoforme* of the series "*Fée à l'ordinateur*"

The object of this game is to explore the space shown by moving a variety of geometric shapes and to organize the space by arranging these shapes as creatively as possible.

### Rationale for the Choice of Software

We deemed it appropriate to explore this avenue since one of the goals of the **Introduction to Mathematics**[16] program is to make the students aware of spatial relationships (proximity, relatedness, size and shape discrimination, and so on) and to give them a better understanding of the geometric movements and relationships that can be observed in space.

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[16] Québec, ministère de l'Éducation, Booklet H of the curriculum guide for elementary school mathematics. **Introduction to Mathematics**, (Québec: MEQ, 1977).

This software would appear to suggest activities relating to the theme of geometry in that it provides opportunities for the user to identify, compare, and discriminate geometric shapes, and oppportunities to change the position and direction of these shapes, thereby incorporating the concepts of high, low, above, below, beside, side by side, left, right, toward, near, and so on.

The most interesting aspect of this material is the many different experiences that are made possible by the computer. The children are entirely responsible for playing these complex and unusual games; their only tools are their problem-solving skills. By presenting our observations of the children's behaviour, we will try to highlight the importance and the level of the challenge involved as well as the problem-solving strategies used by some of the children when playing these games.

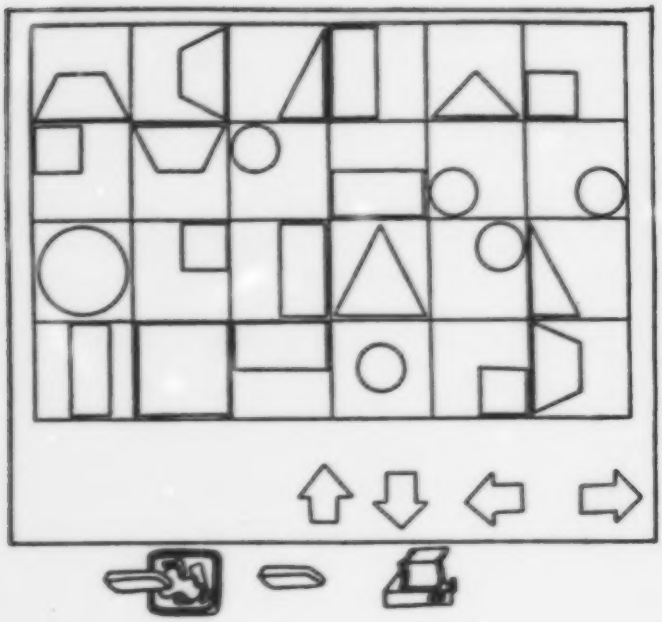
**Description of the Material**

The picture that is placed on the graphics tablet consists of a white space that is blocked off with black lines into 24 boxes containing 24 geometric shapes of different colours: green for round shapes, blue for square and rectangular shapes, red for triangles, and violet for trapezoids. The symbols at the bottom of the page indicate the commands needed to play the game:

- commands to start, stop or recall the menu;
- commands to erase the last element that appeared or the whole drawing;
- commands to place the chosen shape: to the left, right, up, down;
- commands to print the result.[17]

[17] We did not have a printer in class.

On the **computer screen** was a grid pattern with 24 empty boxes.



***Géoforme*** **(6-0)**
Picture on which the child works to try to fill
the empty grid on the screen

**Rules of the Game**

A geometric form appears on the screen when the child pushes the shape of his or her choice on the graphics tablet. Continuous pressure on the picture will cause the form on the screen to duplicate repeatedly (the placement of these shapes is haphazard) until all the boxes are filled.

The directional arrows can be used to move the shape to the desired box. There cannot be two shapes in one box. It is possible, however, to get around the obstacle presented by the appearance of a shape in a given box; by choosing and moving a new shape over the stationary shape, the latter can be made to disappear and will then reappear once the moving shape has passed over. Pressing on the erase key at the moment when one shape is crossing over another will make both shapes disappear.

**First Observation Session of the Children at Play**

The children discovered the different possibilities offered by this game during an initial period of exploration. They learned through cause/effect. For example, they noted that when they pressed too long, they could make little green peas appear everywhere. They erased images, introduced one or more shapes of their own choosing or, at random, began again. Their first strategy was one of discovering and of learning basically how to control their movements.

During a second period of exploration, they asked several questions such as "Why did my ball stop moving?" They positioned their shape in the lower lefthand box of the grid. To continue moving their shape, they had to change their command (using the 'up' arrow, not the 'left' arrow).

By chance they managed to combine different shapes to create new ones that they recognize: houses, boats, two-storey houses, and so on. As soon as they did this, they said they wanted to make something, for example, "I want to make a tree." They were moving from the stage of exploring space to that of organizing it.

In trying to achieve their goal of making something, the children encountered several types of difficulties, namely those of:

- recognizing geometric shapes;

- understanding space that is divided up (the idea of a grid), which introduces the concept of boundary;
- putting shapes together to make new shapes, awareness of the limitations presented by the size of the box; the box always moves with the shape when the latter is moved (discriminating the whole from the parts);
- anticipating the action needed; forming a mental image of the result of combining two forms and of the movement needed to combine them in this way;
- visual anticipation: the children had to mentally locate the path of the shape that disappears when a moving shape crosses over it, for example (in other words, they must recognize that the invisible object continues to exist).

In addition to these cognitive difficulties, the children had problems with movement control: pressing, pressing and holding, letting go. They also had some problem with visual perception, such as determining whether the form was centred or off centre in relation to the box, or whether it was wide, narrow, small, or large; it was also difficult for them to pick out the last shape that appeared on the screen when nearly all the boxes were filled.

It must be noted that these difficulties never discouraged the children from playing. Some of the children who were observed out of class remained involved in the game for 20 to 30 minutes at a time, whereas others appeared to be very satisfied with their explorations and left the computer after five minutes, not out of frustration, but simply because they had finished. Some children appeared to be more interested in the game in class than other students and were frustrated if their turn ended before they had tried out everything that they wanted to.

It is normal for children this age to experience difficulties such as the ones identified above because the task involved in the game requires skills that they are in the process of acquiring or developing. Five- and six-year-old children have already acquired the basic concepts concerning space and are busy developing the thinking processes needed to understand projective and metric systems.

The difficulties experienced by the children when they began playing reflect:

- the complexity of the cognitive processes involved;
- the many challenges presented in this software;
- the variety of hand movements and solutions made possible due to the use of this educational instrument, the computer.

## Teaching Strategies for Complementary and Learning-Transfer Activities

The teacher had a useful role to play in reinforcing and guiding the children's thinking processes. When the children were playing the computer game, the teacher encouraged them to express verbally what they were doing by asking them questions. The main purpose of the questions was to help them think about their actions and to acquire an appropriate vocabulary that would facilitate their thinking and their communication with their peers. Questions such as "Where do you want to go? What do you want to be beside? . . . above? In which box? higher? In the middle? Right at the edge? Towards the house?" provided them with simple vocabulary items for naming the different shapes and directions they would encounter later on.

In order the break the problems down into more manageable parts and to help the children grasp them, we developed a step-by-step learning context for introducing some of the concepts involved in this game. The children were given an opportunity to:

1) familiarize themselves with geometric shapes (in the form of Dienes logi-blocks) on a table;
2) use the blocks spontaneously to make whatever they wanted: houses, snowmen, trees, and so on;
3) arrange and glue different coloured stickers and geometric shapes at will;
4) arrange geometric shapes such as those shown on the graphics tablet within the boundaries of the boxes;
5) play individual games in which they pointed out different directions in space: up, down, right, left, and so on;
6) use some complementary software entitled *"Dirige les amis de Fée"* in the series *Fée et son secret*. This game uses arrows to indicate directions; if the child understands the direction indicated, he or she is able to put the objects in question into boxes that have been predetermined by the game, moving them, for example, to the lower left, the upper right, the lower right, the upper left, all the way to the left, or all the way to the right.

We assumed that this learning situation involving a variety of games would enable the children to make connections and establish relationships, to apply the result of their first geometric and spatial intuitions, and above all, to understand the learning process. It must be pointed out that the game

is always secondary to the main goal of the activity, which is to make the students aware of certain concepts and not to enhance their performance.

## Observations of the Children Playing Complementary Computer Games

### Logi-Blocks

We observed the children handling the Dienes Logi-blocks for a very short period of time. They spontaneously tried to use the blocks to build something, standing the thicker shapes upright and lying the thinner ones flat. What they chose to make depended largely on the size, colour, thickness, and arrangement of the blocks.

When it was suggested that they build something flat, they produced typical constructions of houses, snowmen, and so on. They were happy to work with and explore the new material and to utilize in a new context the skills they had acquired in construction games and drawing.

### Sticker Activity

The above observations concerning the logi-block activity also apply to the sticker activity. The added feature of the sticker activity was that it obliged the children to work in a limited space determined by the size of their sheet of paper. The children were observed to superimpose the stickers in order to create more realistic effects such as eyes and doors (see page 62).

### Photocopy of the Software Picture

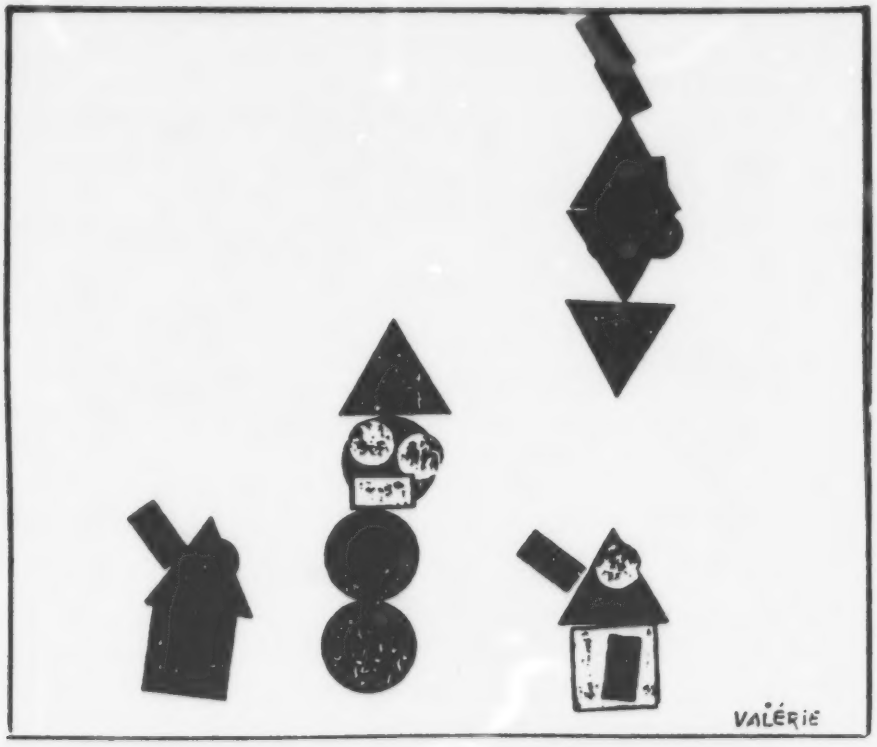
The children were each given a black and white photocopy of the picture in the ***Géoforme*** program. We had them cut up the grid into its 24 boxes as part of an activity to help them overcome their difficulty in grasping one particular concept: the fact that the box and the shape inside it formed a whole that could be moved about as one. The children's instinct was to want to take the shape and get rid of the box.

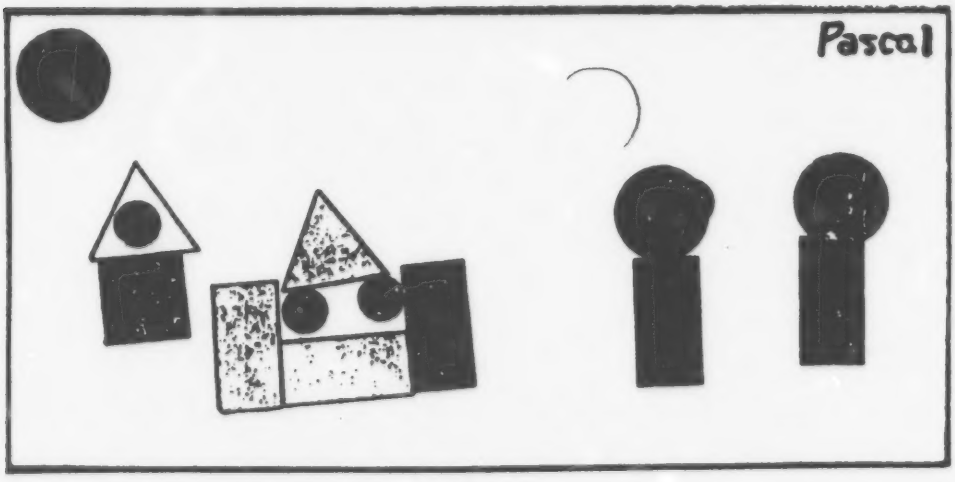
After cutting up their grids, they moved their pieces of paper around, putting different shapes side by side or trying to bring them closer together in one way or another without always succeeding.

Their work revealed the use of different strategies ranging from pairing

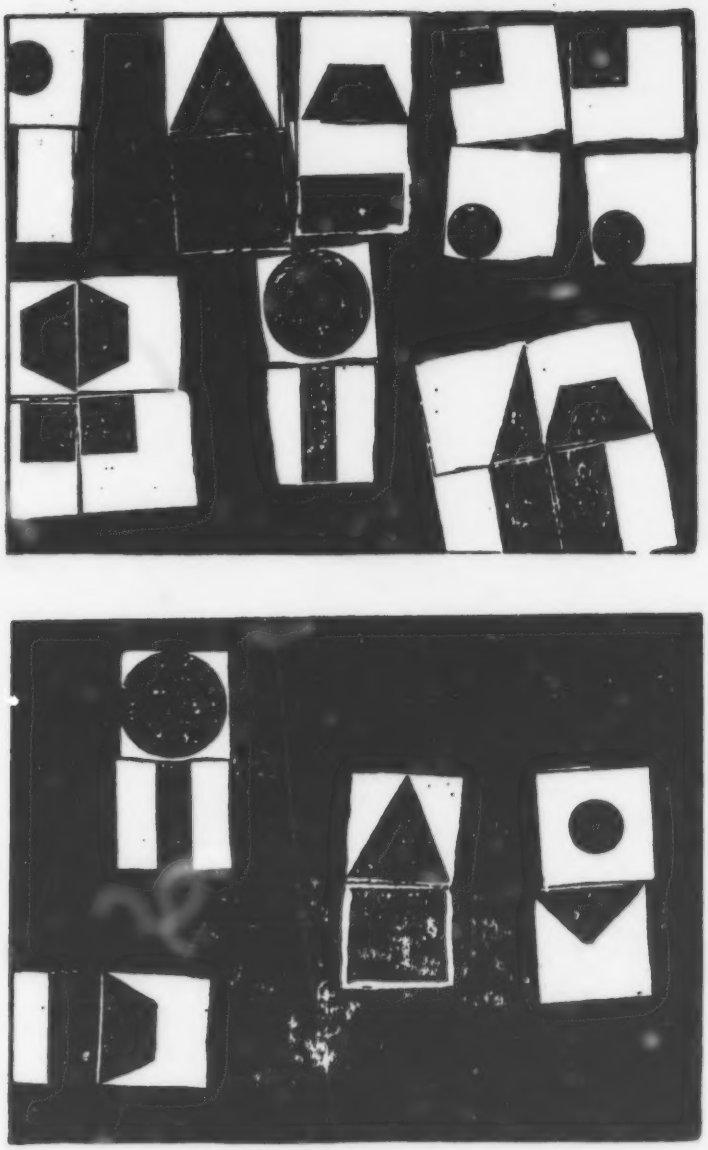
symmetry, repetition, opposition, symbolic representation, to pure chance.

The final products usually gave an idea of what the children were trying to create, and some children would actually say what they had made, for example, " a kite with no tail" or "a road." The presence of white spaces (empty boxes) bothered the children, but they seemed to get over this. By working with small bits of paper, they were able to turn the papers upside down and to pivot their shapes into different positions. Gradually they learned about a new way of organizing space.




Two sticker collages done during free play



Two pictures showing the organization of geometric shapes **after** the children had cut up the grid from the *Géoforme* (6-0) software

It would have been better if the children had had more shapes to work with because they were limited by having only one large round shape and one large square shape, for example, (as when they were playing with the logi-blocks). In contrast, on the computer, they had as many shapes to work with as they wished.

The problem presented was a new one and not all the children were able to understand what they had to do. Overall, we concluded that understanding is the first and most important stage in the problem-solving process, and that the children's understanding must be continually verified or else the point of the activity may be lost or changed: the cutting and pasting activity per se was not the objective.

Following this initial stage of understanding, some of the children developed or intuitively used strategies such as juxtaposing and positioning the shapes in relation to each other: in the middle, to the left, to the right, up or down, repeating shapes or alternating shapes, and so on.

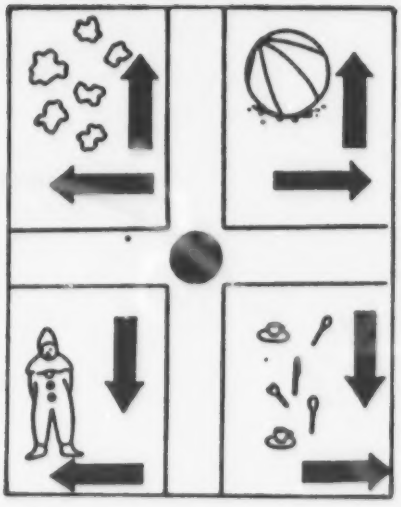
This part of the game lasted around fifteen minutes. It appeared to be a difficult and relatively serious stage because the play element was lacking.

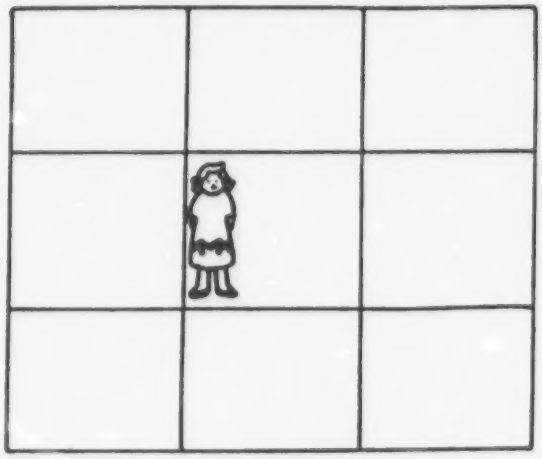
**Exploring Space Through Body Movement**

Individual games in which the children moved their hands or arms in the air were used to help them develop awareness of their bodies and a better appreciation of the phenomenon of movement in different directions. The children enjoyed this activity, which was supervised by the observer.

## SPATIAL ORIENTATION GAME: *DIRIGE LES AMIS DE FÉE* (6-S)

Another computer game involving spatial orientation also proved interesting. The children's curiosity and desire to succeed motivated them to focus their attention on the meaning of the two-headed arrows: upward and to the left, downward and to the right, and so on.





As the children took turns trying to understand the game, their behaviours indicated that it was too difficult for their level: systematic tries; then, through observation, learning the right answers; finally, abandoning the game because it no longer presented any challenge.

In our opinion, this game is better suited for children in the first cycle of elementary school.

These games were spread out over five sessions and alternated with brief spontaneous stints by the children on the computer. In such a brief time, it is impossible to identify behaviours that can be directly attributed to the games; however, we can deduce that repetition and practice on the computer as well as talking about their actions helped the children develop some of the competencies (skills and strategies) needed for game playing.

After observing the children using the *Géoforme* (6-0) program for 10 sessions, we noted that it was a favourite for several of them.

The level of difficulty of this type of program always retains the students' interest as long as they set the achievement level.

The perseverance shown by some of the children was indicative of their satisfaction with their success at overcoming the obstacles, of discovering

new "tricks" on their own. The haphazard explorations that had prevailed during their early contacts with the game diminished greatly, the children who played endeavoured to position or move a shape with or without a particular purpose in mind. They became more comfortable in their use of the **Erase** and **Move** commands. They also developed greater facility in correcting errors and began making fewer errors.

The children still tended to make limited use of the trapezoid shape, a shape that does not remind them of many familiar objects. They continued to make great use of the strategy of putting two shapes together to make a new shape.

Since the observation time was limited, we were not in a position to anticipate the children's future application of what they had learned or their learning progress.

During a short visit to class after an absence of three weeks, one child who was playing on the computer called us over, saying," Come and see. I'm going to make you an apartment building." The child then proceeded, very methodically and without any errors, to build a highly structured grid in which all the boxes were filled with rooves sitting on the main building structure. This indicated that the child had acquired considerable skill in using the Arrow code, because even though he had chosen to work with only two shapes, each time one shape appeared on the screen he had to choose the right directional arrows to place it.

We were unable to assess the exact degree of skill the child had acquired in his movements or in the perception of shapes, but it was clear that he was satisfied at having learning something new and more sophisticated. The child had discovered a building strategy that could be called the "row-house" or apartment-building motif.

At this point in time, we decided that it would be interesting to see whether the children were ready to do their own project on grid paper (with 24 boxes) and to see whether they could plan and carry out this project in cooperation with their classmates. We also wanted to see how a child with a certain degree of skill could help a student with less skill or no skill in that particular area. It seemed likely to us that the best person to initiate a child to a problem-solving situation was another child with more experience or a different perception of the problem. We felt that it was entirely appropriate to have the children work cooperatively in teams, which provide the ideal opportunity for sharing and discussing.

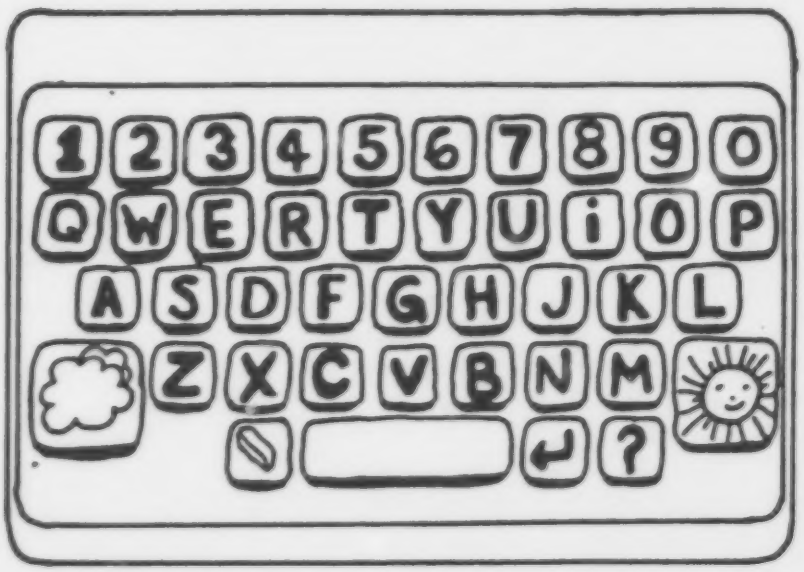
At this strategic point in time when the children are about to learn how to read, this game teaches them the skills they will need for the more complex act of reading: shape discrimination, and the orientation and alteration of elements using their particular ability to express themselves creatively and imaginatively.

**GAME OF SKILL IN RECOGNIZING AND USING THE LETTERS OF THE ALPHABET AND THE NUMBERS FROM 0 TO 10: *TACTOMAGIE* (7-0)**

The free play activities had given the children in the class ample time to choose and explore several of the computer games that attracted them.

They had already had the opportunity to discover a compter game designed to develop reading and writing skills, namely, ***Tactomagie*** from the series entitled *Fée à l'ordinateur.*

**Description and Rules of the Game**




Copy of the picture on which the child can choose the letters and numbers he or she wants to appear on the screen

The picture placed on the graphics tablet is that of a standard simplified keyboard; the same keyboard (with numbers and letters) appears on the monitor screen.

The game involves picking out empty boxes on the screen (they move around) in order to identify which letters or numbers are missing from those boxes. The skills required here are those of shape recognition and correct placement.

The correctness of the answer given is indicated by the appearance of a drawing that moves and by a sound from the computer.

When the child has identified the three **mystery** numbers and the mystery letter, the keyboard becomes functional and can be used for writing or to make a simple discovery. The question-mark key activates the melody indicating that the time for writing is over and that it is time to resume the game of the missing letters and numbers.

**Observations of the Children at Play**

One thing was immediately apparent and that was the children's spontaneous interest and motivation to play this game.

Nearly all the children know the numbers from 0 to 10. Their knowledge of these numbers was reinforced beforehand by their use of the introduction-to-numbers computer game. The children are also able to identify the letters in their names. Some of them recognize other letters as well, such as those that appear in their mother's or sister's names.

Many of the children are familiar with capital letters, having learned to print their names in capitals before starting kindergarten or to recognize some of the letters spontaneously from seeing them on billboards, signs, product labels, and elsewhere.

It must be noted that in the kindergarten class under observation, the children who wanted to learn how to write their names were being taught cursive script because it is the type of writing that is used in elementary school.

The first challenge was learning to recognize the signs (numbers or letters) and the corresponding keys on the keyboard. The children did not have any particular difficulty in pairing and locating the corresponding signs; they

even said that they found this easy to do, despite making a few errors.

By paying closer attention to what they were doing, they were usually able to eliminate these errors.

The children appeared to enjoy playing this game as a transitional step that would allow them free access to the keyboard and to writing.

At this stage of the game, the problem-solving process was quite complex: it was necessary to remember the sequence or order of the letters in the name or word and to find each letter on the keyboard, and then to identify any errors and correct them. Some of the children found it easier to copy the name of a friend, particularly if it already appeared on the screen. They discovered a number of similarities on their own: "I have that one and that one in my name" (they could not remember the names of the letters). Moving from visual similarities to similarities in sound, we were able to help some children recognize that words such as Daddy and Daniel had something in common.

One little girl came up with her own way of applying her new skill to writing; she went around the classroom collecting all sorts of boxes so that she could copy their labels onto the computer (transfer of learning).

What fascinated the children was to see that they could understand the code and that they could transmit messages to adults; they were learning to communicate in a real and different way.

A typewriter was used (no printer was available) to give the children an opportunity to record what they had learned to write and to take it home. Unfortunately ths typewriter did not work very well, the keys were difficult to push down, and the letters did not always come out very clearly; despite these inconveniences, some children persisted in using it with pleasure and determination.

**Followup Teaching Strategy**

in response to the interest triggered in the students by the above activity, the teacher decided to make it even more meaningful by giving each student a little notebook with blank pages in it and suggesting that they enter the names and telephone numbers of their friends.

The children all wrote their own names and telephone numbers on a large

sheet of paper posted on the blackboard. Then, those who wanted to, with help from their friends, copied the names and numbers they wished to keep into their notebooks (which they had decorated with the picture of a telephone).

The teacher told us later that this activity had a very positive effect on the children's interpersonal relations; the numbers and letters had taken on concrete meaning and were no longer abstract realities.

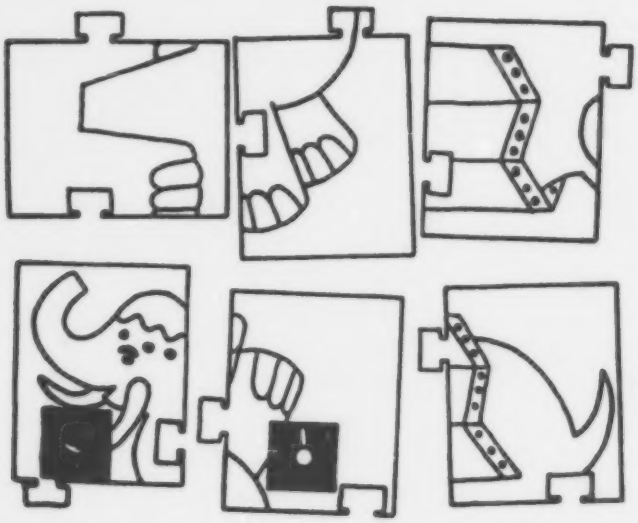
Since the aim of kindergarten is not to teach reading and writing in a systematic way, but rather to respond attentively to the children's individual needs to discover and explore, this computer game was not taken any further by the teacher. However, the children who showed the most interest continued to expolore this educational game and it remained one of their favourites, much like ***Géoforme***.

The interest displayed by these children was a sign of their maturity or readiness for this type of learning. The computer reinforced a natural learning process; it awakened their curiosity, focussed their attention, and motivated them to write.

## GAME INVOLVING ASSEMBLING AND SPATIAL ORIENTATION: THE PUZZLE *ÉLÉPHANTERIE (12-0)*

All children in kindergarten are familiar with traditional puzzles, in which they have to reassemble a number of separate pieces to make a whole. In the computer game, the only way of identifying which pieces go together in terms of shape or picture is by mentally envisaging which pieces need to be moved to which places. We thought it would be interesting to see how children five years of age would handle this challenge.

**Description of the Game *Éléphanterie (3-0)* from the Series "*Fée à l'ordinateur*"**



Copy of the picture on which the children have to indicate the piece of the puzzle they want to appear in the designated area on the screen

This puzzle consists of six pieces that make up the picture of an elephant holding a diskette in his trunk (suggesting the memory found in the computer). The pieces must be fitted together like a standard puzzle; they are presented in random order, with some right side up and others right side down. One piece appears on the screen; the child must find and indicate on the graphics tablet which picture corresponds to this piece. The computer makes sounds to indicate whether the choice is right or wrong.

## The Challenge or Problem[18]

- Identifying the aim;
- Understanding the picture;
- Mentally fitting together the different parts of the picture by comparing the shapes and colours of the pieces and filling in each part of the picture that is relevant to the pieces shown;

[18] The description give here of the skills required in this type of game was based on an analysis done by H. Hetzer and quoted by M. R. Aufauvre (1980).

- remembering the pieces that have already been used and clues such as colour, shape, and the content of the picture,

- Being able to think critically about one's own actions,

- Knowing how to use problem-solving methods such as picking out the edges and the correct position of the notches, and so on

**Observations of the Children at Play**

This unusual presentation of the puzzle problem aroused the children's curiosity and made them want to play. Some of them understood immediately that they had to reconstruct a picture, but without a model to follow, they were puzzled as to what the picture represented. By talking about the picture together, they managed to figure out that it was an elephant, that it had a trunk, a small tail, and something that looked like a diskette. They then moved into action with these as their only clues.

The first piece that appeared on the screen invited them to add another piece by flashing. The children were not sure which piece to add, but each of them guessed on the basis of what they thought they saw. They found the right answer by chance but did not know how to explain their choice.

A great deal was being asked of them: they had to perform abstract manipulations in their mind, envisaging how to rotate or pivot the different pieces and forming a mental picture of the final result if all the pieces were fitted together as planned. This level of anticipation and abstraction is beyond the capacities of young children.

**Comments**

The important point to note here concerns two aspects of learning: the supposed knowledge of the children for whom the game is intended, and the proven knowledge they have of the task they are being asked to perform.

The problem-solving strategy of exploration and trial and error is indicative of the level of cognitive development that is normal for this age: after initial efforts to establish certain relationships fail, "the child proceeds empirically, since his or her only recourse is to use investigative strategies" (Cloutier, 1981).

The fact that the children's efforts led to successful completion of the

puzzle must not mislead the observer regarding the nature of their performance; "A person cannot know how to use this material to the children's benefit simply by looking at it or even by understanding thoroughly how it is supposed to be used; the person must have played the game himself or herself, have watched it being played, and have supervised others playing it; in other words, he or she must be thoroughly acquainted with it before giving it to the children" (Hélène Brûlé, on puzzles, as quoted by M.R. Aufauvre, 1981).

The children nonetheless derived a great deal of pleasure from this computer game and it honed their intellectual skills in an interesting way. However, we wanted to look at the problem in other terms: that of the children's understanding of the concepts involved in doing puzzles.

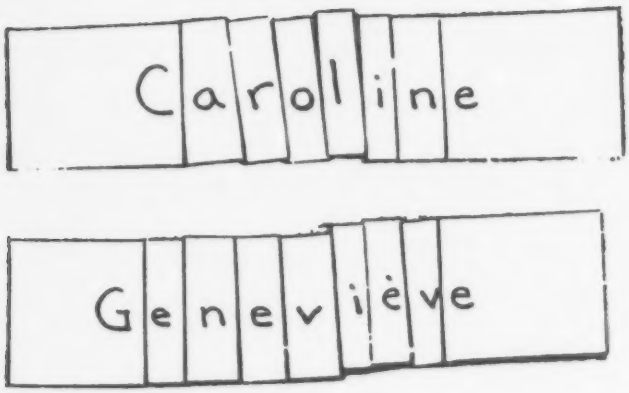
In doing so, it became clear to us how efficient **resourcefulness** (if we can so name the ability to solve problems) is and how useful certain difficult tasks are for diagnostic purposes.

**Context for Developing the Puzzle Theme**

In light of our observations, we created several activities related to the concepts of taking apart and putting together, of the whole and its parts. Our objective was to expose the children to a simpler computer puzzle that came from the series ***Fée et son secret: Fais le Casse-tête, 10 5.***

Examples of some of these game activities:

- Holding a discussion with the children based on the following statement: "My cookie is broken; I can put the three pieces back together and the cookie no longer looks broken." By extension, we encouraged the children to remember things such as toys or plates that they may have broken and glued back together;
- Having the children each do a puzzle comprising four straight-edged pieces cut from a simple picture. The children moved their pieces around a lot before managing to do the puzzle; only one child was able to see the links between two pieces of the puzzle before actually putting them together;
- Presenting more symbolic pictures that were very familiar to the children at this point in the school year (third trimester): the children's first names. Each child was given the letters in his or her name written on separate pieces of paper and had to put them in order to form his or her name.



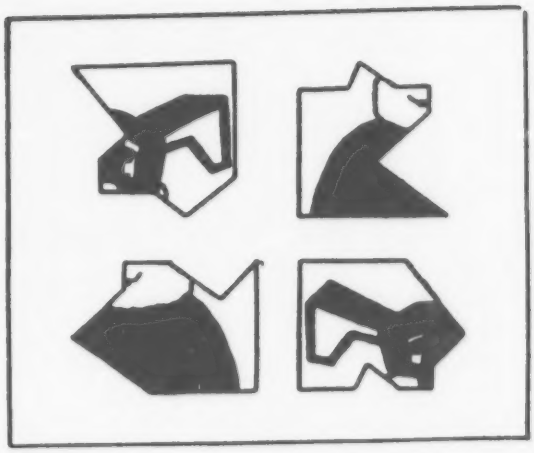

The work of two children who pieced together their names from the separate pieces of paper

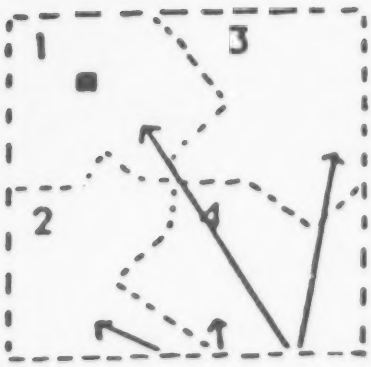
Nearly all the children did this particular puzzle well. We believe that , for the most part, the children's overall perception of their name became more analytical and that this game gave them a better grasp of the concept of the whole and the parts, of the separate element and the entity.

There are many possible activities that could be done prior to doing computerized puzzles in order to break down unfamiliar problems into more manageable parts. Some of the computer games in this collection are designed specifically to provide practice in visual memory, for example, in observing similarities and differences, spatial orientation, and so on.

We did not have enough time to develop this theme any further. We would like to have had the class do the puzzle game described earlier; it appeared to be easier to do: four pieces are placed in front of the child (none are upside down), one piece that should go on the left side is placed on the right side, and one that should go on the top is placed on the bottom, the outline of the pieces is marked in dotted lines on the screen, and, the child can be given a overlay for the graphics tablet that shows the picture he or she is to make. Unable to observe in class, we watched a 5 1/2 year old child do this game without much difficulty in a small session, but we could not reach any conclusions on this basis.

"Fais le casse-tête"





## CHAPTER FIVE

## SUMMARY AND CONCLUSIONS

This experiment on the educational use of computers in the kindergarten classroom comprised an **educational event** which we studied for the purpose of determining the compatibility of computer learning with an active discovery-oriented learning process known as PROBLEM SOLVING.

Our observations of the children's behaviour focussed on the interactive characteristics of the computer, of the learning situations presented in the different computer programs, and of the children's social behaviours and their relationships with the teacher or other adults present.

It was noted that the computer games generated great interest and motivation in the children. Right from the beginning, the programs appeared to provide a context that was conducive to the development of problem-solving skills: by encouraging the children to act and make decisions, by guiding their actions (through feedback), and by providing reinforcement (through acknowledgement of their success).

Most of the children became comfortable with the machine very quickly and were soon able to use it independently. This ability to familiarize themselves so quickly with the computer, computer vocabulary, and some of its different uses reflects children's capacity to adapt to a new medium inasmuch as it satisfies their curiosity and their need to explore, both at a level appropriate to their abilities.

The children developed self-discipline and method as they learned the basic rules concerning computers: the order of operations, the meaning of the symbols, the need to adapt to the pace of interaction, strategies for resolving certain technical difficulties.

They showed much more patience and perseverance than is usually seen in children their age; none of them gave up in the midst of a game, and most of them were set on trying to play the game without making any errors, even when this meant beginning over and over again.

One of the children in the class described the computer in this way: "At home, the computer is for working, at school, it's for playing."

This initiation to computers through games generated positive attitudes involving surprise and wonder, leading to the discovery of solutions, the mastery of problems, and satisfaction at achieving success in the stimulating presence of their peers and co-players.

It was the play or fun aspect of the computer games that in our view generated and sustained the concentration and inquisitiveness required of children in this type of activity.

It is also important to note that the use of the graphics tablet and plasticized overlays allowed the children to communicate immediately and directly with the computer in the simplest and most appealing way possible.

The different software we used in class seemed to us an excellent way of conveying content because of their different sensory qualities (graphics, colours, animation), motivational qualities (challenge, fantasy, curiosity), and the possibility they allowed for individual control (variable pace, high response rate, immediate feedback).

For the most part, these computer games require cognitive skills that preschool children have already acquired or are in the process of acquiring. These skills include association, differentiation, establishing correspondences or relationships, as well as spatial and geometric exploration, letter and number recognition, and uninhibited creativity.

The levels of difficulty in the challenges or problems presented in the games ranged from very simple to complex. The difficulty depended on the age and developmental level of the child playing, his or her prior experiences, and his or her maturity. The problems presented were either common, uncommon, or unfamiliar. In some cases where the children managed to find the solution relatively quickly, the problem quickly became less significant and eventually disappeared; in other cases, the challenge remained.

The very nature of these educational games seemed to us to call on the children's problem-solving skills in that they required attentiveness,

observation, memory, and an effort to understand, all skills that are neccesary to being able to see the links between the elements presented.

Each student's more or less rapid progress toward the solution was assessed in terms of the number of errors he or she made while playing the games.

Some children made decisions in each step of the computer game after first observing the effects of their actions in an effort to determine cause-effect relationships or when verifying a hypothesis. They usually understood the problem presented. The children had the opportunity to discuss their ideas with their classmates, and this sometimes helped them make decisions and revise their earlier hypotheses.

Such learning situations may meet the criteria for **good kindergarten-level problems** as they are described in G. Goffin and C. Tull (1985), one of the main reference works consulted in this study.[19]

However, in our opinion, there are certain conditions which must be present in order to foster the success and positive contribution of computer games to the educational process, conditions which imply the teacher's active involvement in the computer activities as in all other classroom activities.

The teacher has another role to play with regard to computer activities: that of overseeing all the proposed computer activities, activities that could be seen collectively as a **toybox for young minds.**

In her or his strategies, the teacher must allow for the following: the children's need to familiarize themselves with, explore, and handle the new material (as with all other classroom material). Initially, simple short games should be used to provide a gradual introduction to computers. Then, specific skills or programs could sometimes be combined (mazes and shape recognition, for example). Finally, more difficult programs involving different possible solutions could be presented.

The tricky question of knowing whether a child is ready or not for a certain learning experience is solved here because the children make their own choices in keeping with their own pace, interests, and cognitive abilities. These choices reflect their level of maturity, their aptitudes, and their own

[19] Cf, page 21.

problem-solving strategies in approaching a problem.

In terms of the choice of computer games, it is interesting to note that after the initial period of familiarization, the children tended to prefer games which offered the widest possible variety of solutions to explore, and which allowed them to set their own personal goals and to use their creative thinking abilities and intuitive reasoning. The program ***Géoforme (6-0)*** mentioned in Chapter Four is one such example. We also believe that this type of program could serve as an introduction to geometric turtle language (Logo), which creates numerous difficulties for young children when used as a direct introduction to the computer.

It is the child who actively controls the learning process in computer games, and it is this control which enables him or her to develop the all-important intellectual autonomy.

The teacher's role is not to interfere in the children's personal discoveries but to help them express the relationships that they succeed in identifying by manipulating two-dimensional representations of concrete objects on the computer.

By encouraging verbal expression, the teacher helps the children to verbalize the steps they take and to review what they have done. This kind of reflection helps the children become aware of their thinking and reasoning processes and to verify the premises.

Also, by encouraging the children to talk about their new discoveries and to apply them in concrete action during the course of classroom games and activities, the teacher creates conditions that promote the transfer and reinforcement of learning. This seems to be a good way of breaking down problems into more manageable parts and of making the learning experience even more meaningful.

The introduction of computers into the kindergarten classroom is a trend that is likely to continue, given that computers are so commonplace in today's society and that they are already a confirmed part of the children's environment.

The third objective of the Québec preschool program is to help children

INTERACT WITH THEIR SURROUNDINGS. In our view, the use of computers fits in very well with this objective as a complement to other means used to attain this goal.

We believe that the use of computers and of adapted computer games or software can help children acquire meaningful information and knowledge about the world they live in. Computer activities can play a part in satisfying the intermediate objectives identified in the program[20]:

- to use their senses to explore their surroundings;
- to recognize similarities and differences;
- to recognize relationships (develop judgement);
- to formulate hypotheses (what would happen if...?);
- to seek out information;
- to experiment (through play);
- to learn how to use various resources (to vary the types of experiences they have and apply what they have learned);
- to express significant information verbally and non-verbally (an important step in the learning process as it consolidates the skills and knowledge being acquired);
- to use objects and resources in a constructive and original way (certain games foster creativity);
- to arrange their activities in a sequence based on this information (make choices that are consistent with the goal being pursued).

Though conducted over a short period of time, this exploratory study allowed us to formulate and analyze a number of hypotheses from which it can be inferred that computers do create a learning environment which encourages exploration and discovery. It is therefore logical to assume that problem-solving skills and strategies were developed by the children observed in this study. It is our belief that the children effectively discovered new relationships between information, knowledge and their environment. This awareness would appear to generate positive, receptive attitudes toward the computerized learning experiences that the children will have later on in elementary and secondary school.

This teaching/learning approach by means of problem solving will most

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20 Québec, ministère de l'Education, **The Curriculum for Preschool Education**, Code 16-1080A (Québec: ministère de l'Education du Québec, 1981).

likely lead to the development of computer activities geared to the preschool level: **the more this software appeals to children's capacity for inventive action, at the appropriate level of understanding and through play, the more they will help children to understand the relationships that exist in the world around them.**

The interest shown by the teacher[21] and parents in continuing this type of teaching/learning approach is indicative of their openmindedness to the presumed educational value of computer technology.

Studies on the educational use of computers at the kindergarten level are still few in number, and more must be conducted. They should be interdisciplinary, with educators, psychologists, education specialists, and software writers working toether and sharing their ideas and expertise.

Throughout this study, computers were considered as tools that supplement and complement the materials and strategies presently being used in the kindergarten classroom. It would be interesting to develop new types of activites that make full use of the computer's capabilities, particularly, that of creating and reproducing motion.

More questions need to be asked about the smoothest ways of integrating computers into kindergartens for both teachers and students. More work is also needed to shed light on the role teachers should play in the integration of computers in the classroom. A whole new teaching approach, from attitudes to the management of instructional materials, needs to be thought out. Further studies could look at the relevance of certain types of educational computer activities as prerequisites for programming, or at the role of a peer as tutor for the child who is experiencing problems. Many other interesting questions still need to be answered in relation to the integration of computers into the kindergarten classroom.

Any new philosophy or approach in early childhood education must be implemented with caution, but also with imagination based primarily on a knowledge of young children and of the objectives being pursued in their education.

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[21] See: Appendix B, **The Kindergarten Teacher's Assessment.**

## BIBLIOGRAPHY


AUFAUVRE, M.-Renée (1980). Apprendre à jouer, apprendre à vivre. Paris: Ed. Delachaux et Niestlé.

BASQUE, Josiane, MAHY, Isabelle (1983). Guide de création de didacticiels. Applications pédagogiques de l'ordinateur. Varenne: Ed. Graficor.

BESTOUGEFF, H., FARGETTE, J.-P. (1984). Enseignement et ordinateur. Paris: Ed. Cedic/Nathan.

BOCK, Alfred (1981). The Computer in the School: Tutor, Toll, Tutee. New York, Ed. Taylor, R.

BUXTON, M.S., TAITT, H.A. (1982). Microcomputers: A creative Approach for Young Minds, in The Computer: Extension of the Human Mind, Proceedings Annual Summer Conference. College of Education, University of Oregon.

CAMPBELL, P.F., FEIN, G. (1986). Young Children and Microcomputers. Englewood Cliffs: Ed. Prentice-Hall.

CHAUVIN, J., EIMERL, K. (1984). Le jeune enfant et le micro-ordinateur. Centre Mondial Informatique et Ressources Humaines. Paris: La Documentation Française.

CLEMENTS, D.H., GULLO, D.F. (1984). Effects of Computer Programming on Young Children's Cognition. Journal of Educational Psychology, 6, Vol. 76, 1051-1058.

CLEMENTS, D.H. (1985). Computers in Early and Primary Education. Englewood Cliffs: Prentice-Hall.

CLOUTIER, Richard (1981). Le développement cognitif de l'enfant, Introduction à la psychologie de l'enfant, vol. 2, Bruxelles: Ed. Pierre Mardaga.

COHEN, R. (1982). Plaidoyer pour des apprentissages précoces, Paris: Ed. Presses Universitaires de France.

DE FLANDRE, C. (1986). Une démarche de résolution de problèmes réels. Liaisons, Vol. 10, 2, 17-29.

DESTROOPER, J. (1985). Nouveau dialogue avec l'ordinateur. L'éducation par le jeu et l'environnement, 18, 17-19.

ESTES, W.K. et all. (1985). Nature of Problem-Solving Abilities, in Handbook of Learning and Cognitive Processes, Vol. 5 - Human Information Processing. Hillsdale: Ed. Estes, W.K.

GARON, Denise (1985). La classification des jeux et jouets: le système ESAR. La Pocatière: Ed. Documentor.

GARON, D., BELANGER, A. (1985). Bac à sable ou micro-ordinateur, les services de garde devraient-ils déjà choisir? Petit à petit, vol. 4, 3, 8-11.

GOFFIN, S.G., TULL, C.Q. (1984). Creating Possibilities for Problem Solving, Dimension, 2, 15-20.

GOFFIN, S.G., TULL, C.Q. (1985). Problem Solving Encouraging Active Learning, Young Children, 3, 28-33.

HOFFMAN, Rich (1986). Microcomputers, Productive Thinking and Children, in Campbell, P., Young Children and Microcomputers, Englewood Cliffs: Ed. Prentice-Hall.

HOOT, J.-L. (1986). Computers in Early Childhood Education, Englewood Cliffs, Ed. Prentice-Hall.

KLINZING, D.G. (1985). A Study of the Behavior of Children in a Preschool Equipped with Computers. Rapport présenté à la AERA Convention, Chicago.

KRIEGER, D. (1984). L'enfant aux commandes de l'ordinateur, Paris: Ed. Eyrolles.

LERBERT, G. (1970). Piaget, Paris: Ed. Universitaires.

L'ESPERANCE-LABELLE, M. (1985). Une expérience d'éducation informatique pratique avec de jeunes enfants. L'éducation par le jeu et l'environnement, 18, 17-26.

LORANGER, L. (1985). Enseigner la langue maternelle au primaire. Apprendre à l'enfant à apprendre. Trois-Rivières, Ed. Réseau.

MCLAUGHLIN, D. (1985). Computers and Teaching Thinking Skills. Rapport présenté à la AERA Convention, Chicago.

MICHELET, A. (1972). Les outils de l'enfance, tome 2, La conquête de l'intelligence. Neuchâtel: Ed. Delachaux et Niestlé.

MINISTÈRE DE L'ÉDUCATION (1981). The Curriculum for Preschool Education. (Code 16-1080A). Québec, Direction générale du développement pédagogique.

MINISTÈRE DE L'ÉDUCATION (1977). Booklet H: Introduction to Mathematics. (Elementary School Curriculum Guide). Kindergarten Activities. Québec, Direction générale du développement pédagogique.

MORIN, B. (1985). Résolution de problèmes, in L'enseignement de l'informatique dans l'enseignement du second degré, Actes du séminaire restreint franco-québécois de Sèvres (1984). Sèvres: Centre International d'Etudes Pédagogiques.

MUNRO-MAVRIAS, S. (1985). Personal Computers and the Problem-Solving Skills of Young Children. Thèse de maîtrise inédite, Concordia University, Montréal.

NIEBOER, R.A. (1983). A study of the Effect of Computers on the Preschool Environment. Thèse de maîtrise, Oakland University, Eric Reports.

NOT, L. et all. (1983). Perspectives Piagétiennes. Toulouse: Ed. Privat.

PAPERT, S. (1980). Mindstorms: children, computers, and powerful ideas. New York: Basic Books.

PEPIN, M., LEROUX, Y. (1984). Modèle de création de jeux éducatifs sur micro-ordinateurs, in EAO 84, Actes du 1er colloque scientifique francophone sur l'enseignemet assisté par ordinateur, Lyon, Agence de l'Informatique, 266-289.

PERLMAN, R. (1976). Using Computer Technology to Provide a Creative Environment for Preschool Children. Logo Memo, 24.

PIAGET, J. Three lectures (1964) in R.E. Ripple and V.N. Rockcastle (Ed.) Piaget Rediscovered. Ithaca, N.Y.: Cornell University Press.

PILLOT, J., PILLOT, C. (1984). L'ordinateur à l'école maternelle. Paris: Ed. Armand Colin-Bourrelier.

RICHARD, A. (1979). La résolution de problèmes chez l'enfant. Mémoire de maîtrise inédit, Université Laval, Québec.

SCHWARTZ, B. (1981). L'informatique à l'école, Paris: Ed. Documentation française.

SHEINGOLD, K. (1986). The microcomputer as a Symbolic Medium, in Campbell, P. Ed. Young Children and Microcomputers, Englewood Cliffs: Ed. Prentice-Hall.

SPENCER, M., BASKIN, L. (1983). Microcomputers in Early Childhood Education, Washington: Ed. The National Institute of Education.

TAYLOR, M. (1983). Microcomputers in the Early Childhood Classroom. Eric Reports.

WARNER, S., ROSENBERG, E. (1983). Un enfant ça découvre tout par soi-même. Paris: Ed. Epi.

## APPENDIX A

## TEACHER'S LETTER TO PARENTS

Dear parents:

We are always interested in knowing how your children are enjoying their first year in school. We have no way of knowing this other than observing their attitudes in class and receiving your feedback. It would therefore be very helpful for us to find out what they tell you about their experience in school.

This is the purpose of our short questionnaire. We would appreciate it if you would take a few moments of your time to answer the questions below.

Does your child talk to you about how he/she is doing in school?

often ☐
sometimes ☐
never ☐

What does your child talk about most?

- His/her relationship with classmates?_____
- Classroom activities? _____

Which activities seem to be his/her favourite? (in order of preference):

_____

Have you noticed any influence of his/her classroom activities on his/her behaviour or play at home?

_____

Does your child tell you about things he/she does not like in school?

_____

The computer is a new addition to our kindergarten classroom. Does your child talk about it at home?

_____

Do you have the impression that he/she:

- enjoys this new toy? _____
- is learning something in the process? _____

Do you think computers are useful at your child's age?

_____

Would you like your child to have access to a computer in class next year, in Grade 1? _____

Would you like to receive more information on educational computer activities?

_____

Did your child know anything about computers before starting school?

_____

Has he/she ever "played" with one?

_____

Do you have a computer in your home?

_____

Does a close relative or friend have one?

_____

Has your child ever played video games?

_____

What other kinds of activities would you like to see your child doing in his/her kindergarten classroom?

_____

_____

Did your child have problems adapting to school this year?

_____

Did you have to talk him/her into coming every morning?

_____

Did he/she come home from school tired? _____ happy? _____

Did he/she talk about what he/she did?

_____

What are his/her favourite games in the afternoon at home?

_____

Do you feel that your child is ready for Grade 1?

_____

If not, in which areas do you think there is need for more progress?

_____

_____

_____

The space below has been reserved for any additional comments you may wish to make. Please let us know how you see the kindergarten classroom on the basis of your child's behaviour and what he or she tells you.

Thank you very much for your interest and cooperation.

Paule

## APPENDIX B

## THE KINDERGARTEN TEACHER'S ASSESSMENT OF FIVE- TO SIX-YEAR OLDS USING COMPUTERS

In 1985-86 the students of the Compagnons-des Près d'Issoudon kindergarten used the computer with keen interest.

The "new toy," which had been expected for three months, finally arrived in the classroom at the end of December. Intrigued and fascinated, the children were quickly won over by it; the computer workshop became the focal point where everyone wanted to participate at the same time. (In passing, it should be mentioned that the classroom was divided into different activity areas or corners, where the children could circulate and take turns playing.)

If I were to be asked, "Why have a computer in a kindergarten classroom?", I would be unable to answer. But, if I were asked, "What is the value of the computer?" I could identify the following reasons:

1. The computer is an instrument that is easy to use and care for, and it is sturdy;

2. Using the computer obliges students to develop respect for computer hardware;

3. The computer requires its user to adopt a method in order to manipulate it and a method in the order of the operations used;

4. The computer and the software used allow for two learning strategies:
   - logic,
   - trial and error.

5. The computer is objective or neutral. It presents the "truth", yet does not lose patience (it repeats tirelessly), does not judge, and does not criticize errors. Instead, it indicates consequences or results and allows the user to start over as often as desired.

For this reason, nearly all the students at some time or another made errors intentionally or out of curiosity, to see what would happen. There is no reason to be afraid of making errors, which is probably why the children learned to use the computer on their own very quickly.

In conclusion, I would say "yes" to using the computer in the kindergarten classroom and to its educational potential. The experience of the last few months has been most enriching for me.

Paule

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